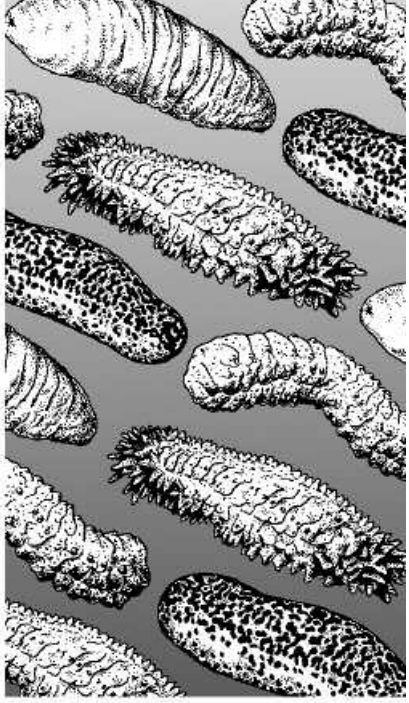

Secretariat of the Pacific Community

ISSN 1025-4943

Issue 25 - February 2007

BECHE-DE-MER information bulletin

Inside this issue

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Produced with financial assistance from the European Union, through the EU/SPC PROCFish project

Editorial

This is the 25th issue and I wish you a very good and fruitful 2007. I must thank all of the many regular and new contributors who helped to keep the *Beche-de-Mer Information Bulletin* a very high quality publication, as well as the dedicated SPC Fisheries Information and Publication Sections' staff who work hard to maintain its quality. The numerous abstracts presented here prove that holothurians continue to attract considerable research in different fields such as biology, fishery management, and aquaculture. The bulletin serves well its goal of linking partners who have an interest in sea cucumbers, worldwide.

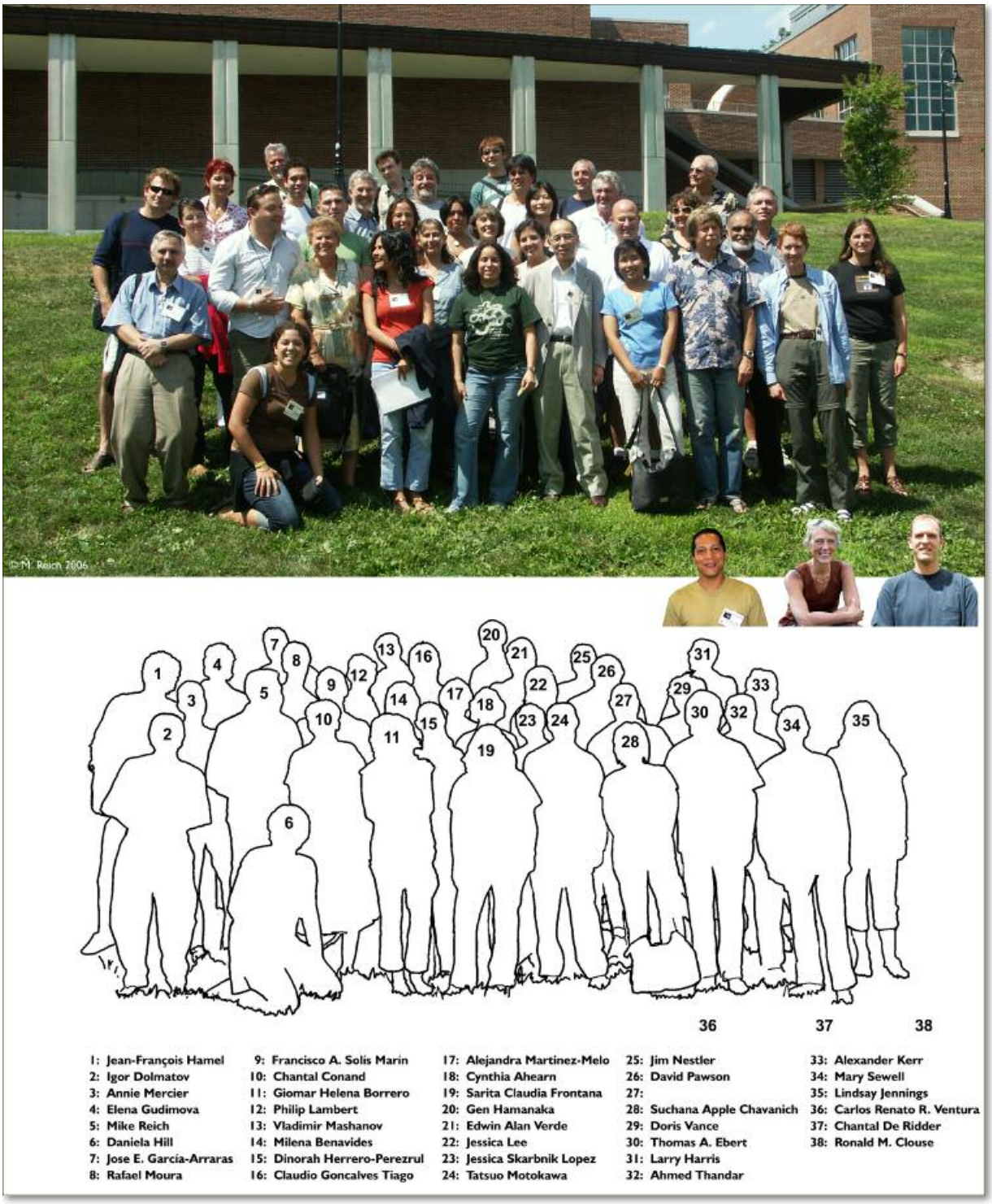
I draw, once again, your attention to the database of all articles and abstracts published in the bulletin to date. This has been put together by SPC's Fisheries Information Section, and is available on SPC's website at: http://www.spc.int/coastfish/news/search_bdm.asp. The database includes around 600 article and abstract titles that can be searched by title, author name(s), scientific name, region or country. Each search result is presented with a hyperlink that allows downloading in pdf format. I also point out that the bulletin is a publication with the ISSN 1025-4943.

This issue begins with the abstracts of oral presentations and posters from the 12th International Echinoderm Conference in Durham (USA), and includes a photo of the sea cucumber scientists who were present (p. 2). It is followed by an article by K.M. Al-Rashdi, which is the first contribution on the sea cucumber fishery in Oman in this publication (p. 17). The socio-economics and management objectives of a three-year sea cucumber project in the western Indian Ocean — which was first presented by Conand et al. in BDM #23 — have been discussed by the team and are now detailed by M. De la Torre-Castro et al. (p. 22). I. Alfonso et al. describe a toxin isolated from the processing byproducts of *Isostichopus badionotus* — a sea cucumber species found in Cuba. The toxin has been successfully tested for skin treatment (p. 29). M. del Mar Otero-Villanueva and V.N. Ut evaluate the sea cucumber fisheries around the Phu Quoc Archipelago (Vietnam) and highlight the need for co-management programmes between countries (p. 32). In issue #24 of this publication, V. Toral-Granda presented an FAO-Darwin Institution programme project aimed at producing fact sheets and an identification guide for commercial sea cucumber species. She presents in this issue the first outcomes of this project (p. 39). There is still a considerable amount of information missing, either on the biology of some of the commercially important sea cucumber species that have been listed, or on their geographical distribution. Toral-Granda makes a call to her fellow colleagues to help her complete the information required.

We continue to publish observations of sea cucumber natural spawnings. In this issue we present detailed observations and photos of *Stichopus chloronotus*, which is described here for La Reunion for the first time (p. 37) by Barrère.

As usual, this and all previous issues of the bulletin are available in pdf format on SPC's website at: http://www.spc.int/coastfish

Chantal Conand



Sea cucumber scientists present at the 12th International Echinoderm Conference, 7–11 August 2006, University of New Hampshire, Durham, NH
(photo and legend by Mike Reich)

12th International Echinoderm Conference, 7–11 August 2006, University of New Hampshire, Durham, NH

C. Conand and M. Reich

Following the 11th Conference in Munchen (cf issue #19 of this bulletin), the 12th conference has attracted many specialists from various countries to the University of New Hampshire in Durham, USA. The sea cucumber scientists were noticed, as there had never been so many!

Prof Larry G. Harris and the organising members are thanked for allowing us to reproduce the sea cucumber-related abstracts here.

The conference proceedings will, as usual, be published by Balkema once all papers have been peer reviewed and accepted.

Mike Reich organised the group photo on the facing page and designed the legend.

Oral presentations

Effect of densities of the sea cucumber, *Holothuria atra*, on chlorophyll concentrations in sediments

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The purpose of this study was to determine the possible effect of the densities of sea cucumbers, *Holothuria atra*, on chlorophyll concentrations in sediments. Both field and laboratory experiments were conducted. In addition, current distributions of sea cucumber populations in Thailand and their habitats were investigated. Individuals of sea cucumbers were collected for the stomach content analysis. Sediment samples and sea cucumbers' feces were also collected from their habitat and then analyzed for chlorophyll a concentrations. The results showed that overall the densities of sea cucumbers in several islands were low, and most were found in the sand areas. Gut contents were composed of sand and molluscan shells. When analyzed for the chlorophyll a concentrations, the results showed that there were differences on the concentrations of chlorophyll a between in the sediment, gut, and feces samples. In addition, in both field and aquarium experiments, feeding activity of *H. atra* significantly reduced microalgal biomass (measured as chlorophyll a concentrations) in sediments. Thus, holothurians have an impact on diatom biomass by an actual consumption, and therefore, their main role in coral reef ecosystem may be the recycling of nutrients, which is an important factor in reef ecology.

The sea cucumber resources and fisheries management in the Western Indian Ocean: current status and preliminary results from a WIOMSA regional research project

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The sea cucumber fisheries of the Western Indian Ocean (WIO) have rapidly developed in the last decade and there is currently a general concern by national and international agencies (Fisheries depts, FAO, CITES) about better management and conservation of these fisheries. This has led to the initiation of a regional project with funding from the Western Indian Ocean Marine Science Association (WIOMSA) for a 3-year pluridisciplinary research to be carried out in Kenya, Madagascar, La Reunion, Seychelles and Tanzania. This communication presents a summary of the initial assessment of this study on the state of knowledge on sea cucumbers that will include a review of the current status of the resources in each country where exploitation levels vary along a gradient, from 0 in La Reunion, to high levels of exploitation with variable stock depletion in the other countries. The effectiveness of fisheries management pro-

grammes in each country is also accessed including an analysis of the decadal fishery statistics for the WIO. A synthesis of the main biological parameters of relevance to management for the commercial species including distribution and abundance, reproduction, recruitment and catches as well as socio-economic information including the status of fishers, processing, collectors, local and international markets is also presented. A review of the local and regional research actions and preliminary results are presented. The major outcome will be a better understanding of the sea cucumber resources of the region and the key management issues that will form the baseline management priorities for the region.

A tetracycline study of the *Holothuria atra* (Holothuroidea) at two sites at Enewetak Atoll

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Holothuria atra was tagged with a solution of tetracycline at two sites at Enewetak Atoll: a gutter on Ananij Island and the Quarry on Enewetak Island. Plates of the calcareous ring incorporate tetracycline and interambulacral plates were used to estimate annual growth increments. The shallow gutter at Ananij becomes very warm at low tide whereas the Quarry is deep and is cooler. Mean length of *H. atra* at Ananij Island was 14.5 cm (2.7 sd, N = 610) and at the Quarry the mean was larger (20.6 cm, 7.4 sd, N = 230). Maximum lengths at the two sites were 23 and 42 centimeters respectively. The larger sizes suggested more favorable conditions in the Quarry and hence the hypothesis was that growth would be faster at this site. Size-specific growth of interambulacral ossicles at the two sites was not different. The total body length difference between *H. atra* in the gutter at Ananij and in the Quarry is interpreted as due to the sizes at which fission takes place as well as differences in survival rate at these sites.

The transfer of PCBs into holothurians via plastic particles

*Erin R. Graham**

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Plastic bottles, bags, and other products dumped into the environment are weathered and degraded, causing tiny fragments to break off. Researchers have discovered substantial amounts of tiny plastic fragments on the ocean surface and on beaches, and also have identified plastic in the benthos. In addition to particles, plastic pellets used to manufacture plastic goods are also present in the ocean. Particles and pellets are mistaken for food by many marine org anisms, and the consequences of ingesting plastics are not well known. Plastic in an aqueous medium can, however, absorb and accumulate polychlorinated biphenyls (PCBs) in levels much higher than ambient seawater. I have been working on an investigation to determine if plastic pollution in the form of tiny particles and pellets is another source of PCBs for deposit-feeding holothurians. My experiments are designed to test four hypotheses: 1) plastic particles 250 µm ± 4.0 µm in diameter are present in subtidal sediment where holothurians reside; 2) deposit-feeding holothurians ingest these plastic particles; 3) plastic particles in sediment absorb PCBs; and 4) PCBs are transferred from plastic particles to holothurians when ingested. So far, I have characterized hundreds of plastic pieces in sediment samples from one collection site, and I have confirmed that *Thyonella gemmata* and *Holothuria leucospilota* ingest polyvinyl chloride and nylon particles varying in shape and size, and often in quantities greater than predicted. As I continue with the PCB experiments, I hope to form a more complete understanding of the consequences of plastic pollution on holothurians, and perhaps other marine invertebrates.

Community structure of conspicuous echinoderms of three islands from the Gulf of California, México

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The Natural Protected Area, Islands from the Gulf of California comprises more than 100 islands. Many of them support artisanal fisheries and tourism activities thus representing an important economic source. In La Paz Bay, southward bound the Gulf, there is a complex of three important islands: San José, Espíritu Santo and Cerralvo, whose marine fauna is poorly known. Invertebrates conforms a substantial part of local fisheries, specially mollusks, crustacean and recently echinoderms (sea cucumbers and sea urchins). Echinoderms play an important ecological role occupying various trophic levels, acting as predators, herbivorous or detritivorous. Little is known of the echinoderm fauna of the isles. The objective of this study was to analyze the community structure of conspicuous echinoderms in the three mentioned islands. A total of 140 (25 x 2m) belt transects were used to assess the reef communities. We estimated species rich-

ness, abundance, diversity and evenness. 23 echinoderms were identified (12 Asteroids, 7 Echinoids and 4 Holothurians). San José Island showed the highest values of richness and the most diverse was Cerralvo. Asteroids were well distributed along the islands, but Espíritu Santo had more species. *Phataria unifascialis* was the most abundant. Each island had its own dominant echinoid species, in San José was *Toxopneustes roseus*, *Eucidaris thouarsii* in Espíritu Santo and *Tripneustes depressus* in Cerralvo. The most abundant holothurian was *Holothuria fuscoscinerea*, found in San José and Espíritu Santo, but in Cerralvo was *Isostichopus fuscus*, an important protected species.

Multi-gene phylogeny of aspidochirote holothuroids

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Aspidochirotida is a large order of sea cucumbers consisting of three families and circa 25% of extant species diversity. Most of its members are found either on coral reefs or at great depth. We present a phylogeny of 45 species of aspidochirote holothuroids (13% of ordinal-level diversity) based on PCR-amplified partial 16S, 12S, 28S and H3 gene sequences. Estimated maximum parsimony and maximum likelihood topologies using POY direct optimisations indicated that Synallactidae is polyphyletic and renders Stichopodidae paraphyletic. This mixis suggests that members of the former family experienced at least two parallel losses of planktotrophic larvae, as well as complicates interpretations of the bathymetric diversification in this group. The third family, Holothuriidae, appears monophyletic and consists of two large basal subclades. Surprisingly, several previously unconsidered gross anatomical and ecological characters define these groups. The first subclade, "Bohadschiinae," consists mostly of large, diurnal and epibenthic species with flattened ventrums, while the second subclade, "Holothuriinae," is primarily of more cylindrical, diurnally cryptic to burrowing forms.

To split or not to split? Asexual reproduction and population density of aspidochirotid holothuroids at One Tree Island, Great Barrier Reef

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The pattern of asexual reproduction by transverse fission and population density of four aspidochirotid holothuroids (*Holothuria atra*, *H. hilla*, *H. difficilis* and *Stichopus chloronotus*) was monitored on One Tree Island, Great Barrier Reef. Although the timing differed, fission is a winter phenomenon for all species at One Tree Island. Fission in *H. atra* and *S. chloronotus* populations peaked in August. Fission in *Holothuria hilla* and *H. difficilis* was most prevalent in June and April, respectively. The influence of population density on the incidence of fission was examined by translocating *H. atra* to patch reefs (microatolls) at three density treatments to test the hypothesis that *H. atra* adjusts its reproductive strategy in response population density. The low density treatment (0.25 *H. atra* m^{-2}) had a higher incidence of fission than the high density treatment (1 *H. atra* m^{-2}) but this result was not significant. The mean size (weight and length) of *H. atra* in the microatolls decreased after 6 months due to fission but subsequently increased, surpassing the initial deployment size after 12 months. Presently the demand for holothuroids as beche-de-mer has increased drastically and has lead to the overharvesting of species of high market value. There is now an urgent need for better management strategies for fisheries to maintain sustainable populations of holothuroids as a food resource whilst maintaining their role in coral reef ecology. This depends on understanding their population dynamics.

Quantification of phenolic contents and antioxidant capacity of Atlantic sea cucumber, *Cucumaria frondosa*

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The antioxidant activity (oxygen radical absorbance capacity, ORAC) and total phenols and flavonoids were determined in extracts from digestive tract, gonads, muscles and respiratory apparatus of sea cucumber, *Cucumaria frondosa*, collected in St. Lawrence Estuary by Scuba diving. Total phenols varied from 22.5 to

236.0 mg of gallic acid equivalent/100 g d.w., and flavonoids from 2.9 to 59.8 mg of rutin equivalent 100 g^{-1}. ORAC values ranged from 140 to 800 µmol of Trolox equivalent/g d.w. Best antioxidant potencies were observed in organic extracts from digestive tract, and in acetonitrile-rich fractions obtained from muscles, gonads and respiratory apparatus. The weakest antioxidant potencies were observed with water extracts from digestive tract and respiratory apparatus, and with water-rich fractions from gonads and muscles. A significant correlation was observed between ORAC values and total phenol content found in extracts and fractions of gonads and muscles, but ORAC and phenols were not correlated in digestive tract and respiratory apparatus extracts. ORAC values were significantly correlated ($p < 0.05$) to total flavonoids in all extracts. Successive eluates obtained from solid-phase extraction of water-rich fractions using C_{18} cartridge showed ORAC values (105–500 µmol of TE/g) reaching up to 2.3 times the potency of their parent fractions. Flavonoids are suggested to be mainly responsible for observed activities. The edible part of *C. frondosa* (muscles) provides to consumers an appropriate anti-peroxyl radical protection, but by-products including gonads, digestive tract and respiratory apparatus also showed the moderate antioxidant potential of *C. frondosa* and a possible valorization.

Development of the nervous system in the holothurian *Eupentacta fraudatrix*

Vladimir S. Mashanov[*1], *Olga R. Zueva*[1], *Thomas Heinzeller*[2] *and Beate Aschauer*[2]

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Development of the nervous system of the holothurian *Eupentacta fraudatrix* (a species with lecitotrophic development) was studied using light and transmission electron microscopy, as well as computer-assisted three-dimensional reconstruction. About 36 h after fertilization, numerous ectodermally–derived cells ingress from the bottom of the vestibule into the primary body cavity and form a disk-shaped rudiment of the ectoneural nerve ring. By the end of day 2, the mid-ventral ectoneural radial nerve cord begins to develop. By days 6 to 8, five tentacle nerves and two pairs (dorsal and ventral) of lateral radial ectoneural cords grow out from the anterior and posterior surfaces of the nerve ring, respectively. The mid-ventral radial nerve precedes the others in development and bears a pair of podial nerves close to its posterior end. The mid-ventral and dorsal radial nerve cords are first to develop the rudiments of the hyponeural subsystem. The latter arises from cells, which migrate from the basal region of the ectoneural neuroepithelium into the underlying connective tissue. These cells remain connected with the ectoneural cords via a continuous basal lamina, which surrounds both the ectoneural and hyponeural parts of the radial nerve cords. These observations strongly suggest that the holothurian hyponeural subsystem, as other regions of the metazoan nervous system, has an ectodermal origin. Later, the hyponeural radial nerves develop in the ventral radial nerve cords. Further development leads to growth of all portions of the nervous system and progressive differentiation of the hyponeural and ectoneural neuroepithelia.

Proteins that increase stiffness of holothurian dermis

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The dermis of sea cucumbers is a catch connective tissue that exhibits large changes in mechanical properties: the dermis takes three mechanical states, soft, standard (intermediate), and stiff. A 'stiffening' protein tensilin, has been isolated from dendrochirotid sea cucumbers (Tipper et al., 2003). We purified a similar protein, *H*-tensilin, from the aspidochirotid sea cucumber *Holothuria leucospilota*. *H*-tensilin appeared as a single band with an apparent molecular weight of 34 kDa on SDS-PAGE. Tryptic fragments of the protein had homology to tensilin. The activity of *H*-tensilin was quantitatively studied by dynamic mechanical tests on the isolated dermis. *H*-tensilin increased stiffness of the dermis in the soft state to the level comparable to that of the standard state. However, *H*-tensilin did not alter stiffness when applied on the dermis in the standard state. The subsequent application of artificial seawater whose potassium concentration was raised to 100 mM increased stiffness by one order of magnitude. These findings suggested that *H*-tensilin was involved in the changes from the soft state to the standard state, but not in the changes from the standard state to stiff state. We have isolated and are now characterizing a stiffening protein that induced stiff state when applied on the dermis in the standard state.

Effects of varying temperature-salinity-larval food level during rearing on larval survival, development and post larval yield in *Holothuria scabra*

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Holothuria scabra is a commercially important sea cucumber species, which can now be successfully produced in hatchery. This species has complex life cycle and its larval phase is relatively elusive in plankton tows. Thus, the larval phase remains enigmatic. Breakthrough in the culture of *H. scabra* proved useful in elucidating factors important in larval and early settlement phases. Three factors: temperature, salinity and food level were looked at under laboratory conditions. This study could provide us clearer understanding of its larva and postlarva ecology. Also, this could give useful insights in improving the culture technology of this species. Larval survival was high (78–100%) up to Day 9 after fertilization. None of the three factors showed significant effect on larval survival. However, larval development and metamorphosis was delayed at lowered temperature and food levels. Juvenile yield was greatly improved (50 to 100%) when larvae were reared in cooler waters whether food levels were low or high. When food levels were high, seawater dilution enhanced development and post metamorphic yield at warmer rearing temperature but not at cooler rearing environment. The effect of dilution on juvenile yield was less clear when food was low. The potential implications of these results on larva and postlarva ecology and culture of *H. scabra* shall be discussed.

Origin and early evolution of holothurians (Echinozoa)

Mike Reich

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Compared to their modern counterparts, the palaeobiology and evolutionary history of the nearly 800 paraspecies/species of fossil holothurians are poorly understood. In part this is due to their disjunct skeletal remains, and almost entirely sclerites and calcareous ring elements, which are released following decomposition of the surrounding tissue. However, under favourable conditions, holothurians may be preserved complete in various Fossil Lagerstätten, e.g. in the Palaeozoic and Mesozoic. After recent studies of the author, the oldest unequivocal holothurians are of Darriwilian age (Middle Ordovician). These are isolated calcareous ring elements and associated body wall ossicles of a new arthrochirotid sea cucumber from the so-called Red *Orthoceras* limestone (Kundan stage, *suecicus* conodont zone, Early Llanvirnian, 464 Ma) of Sweden, found as a Geschiebe (glacial erratic boulder) in northern Germany. The new findings plug an important gap in our understanding of early holothurian evolution, and provides the present view of the origin and assembly of the Echinozoa. Because of limited research, a generally accepted hypothesis has not emerged for the phylogeny of the early Holothuroidea as well as Echinozoa. Responsible for the latter was particularly the lack of data from Holothuroidea. The fossil record is a potential source of needed data, although fossil holothurian body fossils are rare, and they tend to be preserved as isolated sclerites only. Therefore, a combination of micro- and macropalaeontological research is urgently needed for future studies.

Here I present an overview on the fossil record and phylogeny for the Early Palaeozoic holothurians. The first representatives of sea-cucumbers (Arthrochirotida) were characterized by an (?)exoskeleton of sieve plates, furthermore plated tentacles, and also remains of an ambulacral system – altogether with apodid affinities, whereas the first unequivocal Apodida comes from the Telychian/Sheinwoodian (Silurian) of Gotland, Sweden, characterized by typical perforated radial elements with myriotrochid affinities. The results have also provided the basis for further studies and discussions on these poorly characterised echinoderm group.

Regeneration of the nervous system in the holothurian *Eupentacta fraudatrix*

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Regeneration of the nervous system in the holothurian *Eupentacta fraudatrix* was studied in two model systems. The first one involves regeneration of the radial nerve cord (RNC), which has been cut transversely at the mid-body level. In the second set of experiments, the animals were induced to eviscerate, i.e. to discard their viscera along with the pharyngeal complex, which includes, among other things, the circumoral nerve ring. At the early stage of regeneration, wound healing takes place in both models. At the same time, numerous cells in the neuroepithelium at the wound site undergo apoptosis, while others dedifferentiate and then begin to proliferate and invade the connective tissue that has been laid down between the wound

edges. In the transected RNC, outgrowth occurs from both nerve stumps. The growing tips of the ectoneural and hyponeural parts of the RNC are composed of dedifferentiated glial cells that form a thin tube. Both regenerates eventually meet and neuronal elements invade the epithelial wall of the tube, thereby giving rise to the neuroepithelium. In the second model, the circumoral nerve ring is restored due to growth and bifurcation of the anterior ends of the ectoneural bands of the RNCs. Following bifurcation, the growing brunches of the adjacent RNCs fuse to from a new nerve ring. At the cytological level, regeneration events are similar to those in the transected RNC.

POSTER PRESENTATIONS

Cocos Island (Costa Rica) echinoderms: a recount of their knowledge

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A systematic list of the echinoderms of the Cocos Island and Cocos Ridge, based on specimens from the Museo de Zoología de la Universidad de Costa Rica, the National Museum of Natural History, Smithsonian Institution, Washington, D.C., the "Dra. María Elena Caso Muñoz" Echinoderms Nacional Collection from the systematic and ecology laboratory of Echinoderms from the Instituto de Ciencias del Mar y Limnología at the Universidad Nacional Autónoma de México, and from the literature is presented. A total of 124 echinoderm species is recorded, distributed in 94 genera, 51 families and 22 orders. The Asteroidea where the richest group with 35 species, followed by the Echinoidea with 30, Ophiuroidea with 30, Holothuroidea with 27, and the Crinoidea with only two species. The Cocos Island posses only two endemics species, the asteroids *Astrpopecten benthophilus* and *Persephonaster armiger*. Eight new records for the Cocos Island are presented: four asteroids (*Asterope* sp., *Leiaster* sp., *Ophidiaster* sp. and *Mithrodia* sp.), one echinoid (*Toxopneustes* sp.) and three holothuroids (*Holothuria hilla*, *Stichopus horrens* and *Chiridota pacifica*). It is also presented a review of all the researchs made on the Island, and we discuss the needs for future projects.

Parasitic disease in larval cultures of the edible sea cucumber *Isostichopus fuscus*

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The present contribution aims at describing a disease that affects larvae of *Isostichopus fuscus*, a valuable, edible sea cucumber found from northern Peru to Baja California. *I. fuscus* was extensively fished over the past decades and it is now farmed in land-based systems along the coast of Ecuador. The disease mainly affects auricularia larvae. During the early stages, opaque cells become visible around the digestive tract of the larvae, soon followed by the collapse of the intestine and stomach. In worst cases, the digestive tract completely shrivels up and disappears, preventing the larvae from feeding. When it occurs, the infection affects 90–100% of the larvae and is usually fatal. Optic microscopy, S.E.M. and T.E.M. indicate that the agent of the disease is an amoeboid protozoan. The protozoa display jerky movements when observed outside the larvae, whereas slower moving, smoother forms appear inside the larvae. During the first stage of the disease, the parasites enter through the body wall and the digestive tract. Later on, they become larger and are present in countless numbers inside and outside the intestine. Parasites are presumed to feed on the intestinal contents and/or tissues, slowly making it shrink and disappear, typically causing the death of the larvae. Once the disease appears, the only somewhat effective treatment consists in raising the temperature of cultures by 1°C. This accelerates the parasites' cycle, making them leave their hosts sooner and enabling some of the larvae to resume feeding. This procedure may save up to 6% of the larval culture.

Echinoderms from Puerto Rico Island: Inventory from shallow water species

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One of the greatest problems concerning marine biodiversity conservation management is the lack of knowledge of species, abundance and distribution as well as a lack of qualified taxonomists to study the

fauna. The echinoderms from the shallow waters of Puerto Rico are similarly abundant and diverse to the other islands of the Caribbean region, but previous studies are few and old. The existing information is reduced to two reports published at the beginning of the 20th century, and some theses and reports published near the end of the century. The principal goal of this study is to update the echinoderms inventory from shallow waters of Puerto Rico based on examination of reference material in the echinoderms collection of the National Museum of Natural History (NMNH), Washington, D. C. and the echinoderms of the Invertebrate Collection of the Marine Department, Puerto Rico University, Mayagüez Campus. In addition, extensive material was collected from La Parguera to the southeastern region of Puerto Rico from coral reefs and sea grass beds with a variety of sandy or rocky substrates. Within this study, a total of 103 species are reported from the shallow waters of Puerto Rico of which 6 species belong to the Class Crinoidea, 14 to the Class Asteroidea, 41 to the Class Ophiuroidea, 14 to the Class Echinoidea and 28 to the Class Holothuroidea. A total of 10 species are reported for the first time, and 52 specific localities are provided. The zoogeographical affinities of the shallow waters of Puerto Rico are discussed in comparison with other studies from the Caribbean.

Perspectives and present situation of sea cucumber fisheries in the Colombian Caribbean Sea

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Knowledge on Colombian Caribbean Sea holothurian species is very limited. Although 36 species have been included into the national inventory, studies on the biology and ecology of these populations are missing. The most complete inventory of shallow water species was made by Caycedo back in 1978, who listed 14 species from the National Natural Park Tayrona and the Rosario Islands, among them, 12 species belong to the Stichopodiidae and Holothuriidae families. Sea cucumber fisheries in Colombia recorded 0.55 ton of dried sea cucumber in 2001, however this amount does not count the increasing punctual captures known from the Santa Marta, Cartagena and La Guajira regions between 2004 and 2006. Based on ossicles revisions and captures photographs is possible to confirm the exploitation of *Holothuria mexicana* and *Isostichopus badionotus*, recognized by its commercial importance in the Caribbean Sea, nevertheless, is not possible to discard the capture of other species. The present situation of the sea cucumber fisheries in Colombia is similar to other countries of the Caribbean Sea, where the fisheries begins with the consent of the governmental authorities without having essential information about its populations. There is an increasing interest on holothurians and several research proposals are starting to discern their most important thematic for its sustainable management and conservation. Aquaculture projects initiatives are also in expansion.

Larval serotonergic nervous system in *Chiridota gigas* (Holothuroidea: Apodida): Juvenile fate and inferences on the evolution and ambulacrarian larvae

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The auricularia larvae of the apodid sea cucumber *Chiridota gigas* develops a comparatively simple serotonergic nervous system consisting of the apical organ at the larval apex and a thin fibre that follows the ciliary band nerve. The apical organ of *C. gigas* forms a concentration of immunoreactivity along, and spanning between, the portions of the ciliary band that traverse the larval apex. Neurons give rise to fibres that connect the bands. In contrast to other echinoderm larvae, serotonergic cells do not develop around the mouth. The similar topology and structure of the apical organ of the auricularia and the tornaria suggests that the serotonergic apical organ of the Ambulacraria (Echinodermata + Hemichordata) may have originated as a group of nerve cell bodies and fibers that developed in association with ciliary band sectors at the larval apex. Serotonergic immunoreactivity is evident through metamorphosis. The apical ganglion appears to split and move laterally in association with development of the juvenile.

The relationship between the shape and distribution of dermal ossicles with habitat selection in some species of Holothuroidea

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The Holothuroidea have a skeleton formed by ossicles, i.e., minute calcareous deposits dispersed within the body wall. Although those structures have great importance as taxonomic characters on this class, lit-

tle is known about the relationship between their shape and distribution along the body with the life habits of the species. In *Duasmodactyla seguroensis* (Deichmann, 1930), *Holothuria grisea* Ludwig, 1867, and *Isostichopus badionotus* (Selenka, 1867), for instance, a higher concentration of ossicles tends to occur in the rear part of the body. It was also observed that, in those species, tower shaped ossicles have the spire tips oriented outwards, whereas the bases rest on the body wall. Since those animals live in close contact whit the substrate, it is reasonable to assume that the ossicles are positioned as such in order to render maximum grasp, helping them to hold firmly to sandy or rocky bottoms. The perforated rods observed on the tentacles of *D. seguroensis*, a species that lives buried in the sand with the tentacles extended on the water column, are parallel to the body wall, helping to support the tentacles. The tube feet's perforated rods of *H. grisea* are arranged in this same fashion, conferring them more strength to hold the animal firmly attached to the substrate. This species is usually found on shallow waters of the intertidal zone, where they have to cope with the strong hydrodynamics of waves and tides.

The two *Phyllophorus* species described by Ancona Lopez (1962): A review

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Ancona Lopez (1962) has described *Phyllophorus palmae* and *Phyllophorus aparecidae*, two holothuroid species; from specimens collected at São Francisco beach (São Sebastião Channel, State of São Paulo, Brazil; 23°44'56"S; 45°24'34"W). However, she never deposited the type specimens. Collections made at the same place in different seasons revealed only two morphotypes of dendrochirotids holothuroids similar to those described in 1962. The first morphotype has ten dendritic tentacles and a calcareous ring composed by ten pieces (the radial ones with two forward projections and the interradial ones with only one); the tube feet have end plates, perforated rods, baskets and buttons; the tentacles have rosettes, perforated rods and baskets; and the body wall possess only baskets. The second morphotype has twenty dendritic tentacles and a calcareous ring composed by ten pieces (the radial ones are quadrangular and the interradial ones oval, with a long forward projection); the tube feet from the introvert and anal regions have end plates, towers with circular, extended or triangular bases, while the tube feet of the medium region of the body have end plates and towers with circular bases; the tentacles have rosettes of different sizes and perforated rods, while the body wall have only towers with circular bases. Therefore, through the analysis of the calcareous structures and of the general anatomy of the specimens studied, we concluded that *P. palmae* and *P. aparecidae* should be considered as junior synonyms of *Ocnus surinamensis* (Semper, 1868) and *Duasmodactyla seguroensis* (Deichmann, 1930), respectively.

Stem cells of holothuroid coelomocytes

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The special type of small motile cells (SMC) was described in the connective tissue of several organs in the holothurians *Eupentacta fraudatrix* and *Apostichopus japonicus*. These cells are characterized by small size, dense and elongated nucleus, high nucleus to cytoplasm ratio and narrow rim of the perinuclear cytoplasm, which contains centrioles. There are some transitional morphological stages between the SMC and amoebocytes and spherule cells. Moreover, we showed that the SMCs begin to synthesize DNA (to incorporate 5-bromo-2'-deoxyuridine or ^{3}H-thimidine) and migrate into the body cavity shortly after evisceration. Later, the SMC begin to differentiate and give rise amoebocytes and spherule cells. Therefore, the SMC can be considered as stem cells of the holothurian immune system. The function of the cells is maintenance of coelomocyte population during animal life and after severe injuries, for instance, evisceration.

The nervous system component within the connective tissue of holothurians

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The echinoderm nervous system is one of the least studied of the metazoans. Our lack of knowledge is partly due to the limited tools available to study the nervous system of this phylum. We have now produced a monoclonal antibody that labels a nervous system component of *Holothuria glaberrima*. Western blots show that our antibody recognizes a major band of 66 kD and a minor band of 53 kD in radial nerve homogenates. Immunohistological experiments show that, in *H. glaberrima*, the antibody distinctly labels most of the known nervous system structures and some components that were previously unknown or

understudied. One of the most surprising findings was the labeling of nervous plexi within the connective tissue compartments of all organs studied. Extensive fiber networks were observed, as well as some immunoreactive neuron-like cells. Double labeling with an antibody against the holothurian neuropeptide, GFSKLYFamide, showed that RN1 labeled most, if not all, of the neuropeptide containing fibers, but also a larger component of cells and fiber that did not show GFSKLYa immunoreactivity. The presence of a distinct plexus associated with the connective tissue in holothurians is highly significant in view that these organisms are known to posses a mutable connective tissue and that the changes in the viscosity of the connective tissues have been proposed to be under the control of the nervous system. Therefore, the cells and fibers recognized by our monoclonal antibodies are probably the cellular entities responsible for the control of echinoderm connective tissue contractility changes.

Gonadal morphology and oogenic stages of *Cucumaria frondosa* from the Barents Sea: Comparative aspect

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The main aim of study was to establish both morphological and histological conditions of reproductive system of sea cucumber *Cucumaria frondosa*, and to compare them with previous data (Oganesyan, Grugorjev, 1996; Gudimova, 1998). *C. frondosa* has been collected at a number of stations in the coast and offshore line of the Barents Sea during 2004–2005. Morphology and oogenic stages of gonads from different populations of the Barents Sea were investigated. Individuals with a body-wall mass 25 to 200 g were examined. Upon reaching body wall mass of 47 to 60 g, animals attained their sexual maturity and their gonads developed a clear sexual dimorphism. The ratio of females to males did not differ significantly from the expectation of equality. During examination of gonads was noticed that *C. frondosa* from the Barents Sea is a gonochoric species in general, however some evidence of hermaphroditism being found. Macroscopically it is possible to see the ovary in different stages of development. The gonads of adult *C. frondosa* from the Barents Sea were divided in three classes of numerous (98 to 470) gonadal tubules: small (0.15–0.5 mm), middle (0.6–1.5 mm), and large (> 1.5 mm in diameter). Spawning of *C. frondosa* occurs in March at west part and in summer months at east part of the Barents Sea. It was supposed the large tubules, and sometime the middle one, releases ripe oocytes (reaching to 800–950 µm in diameter), while the small ones are not implicated in spawning events. The total fecundity of examined adult animals (in February) reached 60,000 to 150,000 oocytes per individual. The number of mature oocytes in gonad reached 8,600 to 31,400.

Evidence of aberrant oogenesis in a temperate holothurian

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Sea cucumbers *Cucumaria frondosa* were collected in the St. Lawrence Estuary (Quebec), in the Gulf of St. Lawrence and along the southern and eastern coasts of Newfoundland, eastern Canada. Unusual structures were detected on the external peritoneum of the gonadal tubules in ca. 5–10% of the females. The condition varied from mild to severe, with hundreds of pale masses scattered from the basis to the tip of the gonad. A localized castration was observed in heavily affected tubule sections. Investigation of the structures using histology, transmission electron microscopy (TEM) and gene analysis revealed that they were oocytes at different stages of their development, growing singly or in groups of up to 7. Their size was consistent with that of oocytes found in the lumen of the gonadal tubules. TEM sections clearly showed that the atypical oocytes emerged from the peritoneum and matured toward the coelomic cavity, and that they were not in contact with the basal lamina and the inner germinal tissue layers. Follicular cells were found between the "exo-gonadic" oocytes, whereas they are present all around traditional oocytes. These results indicate that primordial germ cells and developing gametes can occur outside the normal site, without interaction with the genital haemal sinus. Because *C. frondosa* specimens were collected from various locations, including pristine areas of the North West Atlantic, it is unlikely that the occurrence of these "exo-gonadic" oocytes is linked to pollution or other anthropogenic activities. Further investigation will be required to clarify the meaning of this atypical oogenesis.

Fine structure of the polian vesicle in the holothurians *Eupentacta fraudatrix* and *Cucumaria japonica*

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The fine structure of the Polian vesicle was examined in the holothurians *Eupentacta fraudatrix* and *Cucumaria japonica*. The wall of the Polian vesicle is composed of three layers: the innermost is the water vascular mesothelium, the connective tissue layer is subjacent to this, and outermost is the perivisceral mesothelium. Both mesothelia are typical pseudostratified myoepithelial composed of peritoneal and myoepithelial cells. Numerous myocytes of the water vascular mesothelium constitute a powerful circular musculature. In the perivisceral mesothelium, the myocytes are much less abundant and lie parallel to the axis of the organ thereby forming a longitudinal musculature. The contractile system of the Polian vesicle is innervated by a basiepithelial plexus associated with the perivisceral mesothelium. In the water vascular mesothelium, neither neuronal perikarya nor processes were found.

Long-term study of gamete release in a broadcast-spawning holothurian: Predictable lunar and diel periodicities

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Annual and monthly patterns of gamete release by the sea cucumber *Isostichopus fuscus* on the coast of Ecuador were studied to determine the proximal spawning cue and variations in the reproductive output throughout the year. Several hundred newly collected individuals were monitored nearly every month for 4 years. *I. fuscus* displayed a lunar spawning periodicity: 0.7 to 34.9% of individuals consistently spawned 1–4 days after the new moon. Most spawnings occurred on the same evening, although some gamete release was often recorded over 2 to 4 consecutive evenings. Individuals maintained in captivity for several months retained their spawning periodicity and timing with the lunar cycle. Inversely, newly caught individuals that were shaded from the moonlight did not spawn, thus showing the apparent lack of endogenous rhythms and the prevalence of moon luminance over other cues (i.e. tidal cycle, fluctuations in barometric pressure). On a spawning night, males typically initiated gamete release around sunset; females spawned just after the peak male broadcast. The percentage of spawning individuals was higher and a greater overlap between male and female peak spawning activity was noticed during clear conditions compared to overcast conditions. The gonads of individuals that did not spawn in a given month showed a variety of maturity levels, including post-spawning, growth and mature gametogenic stages. Hence, the individual reproductive cycle is apparently longer than the monthly spawning periodicity observed at the population level.

Synallactidae (Echinodermata, Holothuroidea) from Campos Basin, Southwest Atlantic

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Recently, the oil and gas industry initiatives have contributed to increase the knowledge of the Brazilian deep-sea fauna. Samples and ROV images of synallactid holothurians have been collected from the Brazilian Continental Margin through two projects: the Campos Basin Deep-Sea Environmental Project, and Campos Basin Deep-Sea Coral Assessment Project -CENPES-PETROBRAS. *Pseudostichopus depressus*, and *Mesothuria* sp. were the only synallactids recorded in Campos Basin from 700–2000 m. *P. depressus* is a small holothurian mainly characterized by a distinctive rim that surrounds its flat body which is mostly covered by foraminiferans. Body wall deposits are rare or completely lacking, except for some braided curved rods from the tentacles in the 8 specimens examined. A total of 48 specimens of *Mesothuria* sp. were examined. Calcareous deposits include exclusively quadriradiate tables from the body wall and straight and slightly bent spiny rods from the tentacles. Four sedentary individuals of *Mesothuria* sp. were observed during ROV transects at depths greater than 1000 m. All of them had their bodies partially encrusted with pteropod shells, sharp sponge spicules, and black unidentified small pebble-like structures. The genus *Mesothuria* comprises about 36 described species and so far had never been reported for the Brazilian con-

tinental margin. Identification keys for synallactid holothurians, especially some species of the genus *Mesothuria*, require accurate review. Sampling and conservation methods may strongly affect the quality of the synallactids external morphological characteristics. This could influence the identification process. Combined taxonomy and imaging of live specimens may help understanding the main features of the organisms studied.

Collection of Echinodermata from the Zoology Department, Institute of Biology, Federal University of Rio de Janeiro, Brazil: Holothuroidea

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In the 50s, Dr. Ignacio M. Brito initiated the collection of Echinodermata collection from the Department of Zoology at the Institute of Biology, Federal University of Rio de Janeiro (UFRJ), which has been increased over the years. This collection consists on over 3,400 lots, which correspond to around 10,000 specimens of shallow and deep-sea water echinoderms, from which 233 comprise holothuroids. These have been classified into 12 families and identified as follows: Psolidae [*Lissothuria braziliensis* (n=1)]; Phyllophoridae [*Neothyonidium parvum* (n=5), *Phyllophorus palmae* (n=15), *Thyone pseudofusus* (n=1)]; Sclerodactylidae [*Euthyonidiella dentata* (n=17), *Pseudothyone belli* (n=2)]; Cucumariidae [*Ocnus pugmaeus* (n=2), *Thyonella sabanillaensis* (n=1), *Thyonella surinamensis*(n=1), *Trachythyone crassipeda* (n=25), *Cucumaria pulcherrima* (n=7), *Duasmodactyla seguroensis* (n=9)]; Holothuriidae [*Holothuria grisea* (n=51), *Holothuria parvula* (n=1), *Holothuria surinamensis* (n=4), *Holothuria arenicola* (n=2)]; Stichopodidae [*Isostichopus badionotus* (n=9)]; Synaptidae [*Protankyra benedeni* (n=265), *Synaptula hydriformis* (n=11)]; Chiridotidae [*Chiridota rotifera* (n=107)]; Caudinidae [*Paracaudina chilensis* (n=7)]; Deimatidae [*Deima validum* (n=49)]; Synallactidae [*Pseudostichous depressus* (n=8) *Mesothuria* sp. (n=48)], and Molpadidae [*Molpadia* sp. (n=50)]. Around 70% of the lots came from the Brazilian continental shelf. A total of 23 deposited holothuroid species belong to Southeast Brazil. All this information has been checked and re-organized so that it can be aggregated to internet databases such as the Ocean Biogeographic Information System (OBIS). The collection of Echinodermata is already registered in the Brazilian Reference Center on Environmental Information (CRIA) (http://www.cria.org.br/zoo/lista?action=show&id=ZOO1139453276). This work represents a contribution to the knowledge of the holothuroids recorded in Brazil.

Diel cycles of activity, metabolism, and nutrient production in tropical sea cucumbers

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Sea cucumbers (Holothuroidea) influence ocean communities by affecting physical and chemical characteristics of sediment through their deposit feeding activities. We examined diel cycles of *in situ* movement, metabolism, and ammonium production in *Pearsonothuria graeffei* and *Holothuria edulis*, two species inhabiting coral reefs in the Philippines. Data were collected during day and night at depths of 12–20 m using scuba. Movement was measured by determining linear displacement every 2 h for a 6h period. Oxygen consumption was determined by placing animals in an underwater respirometer for 2 h. Ammonium concentration was measured in water withdrawn from the anus during respiratory exhalations. *P. graeffei* had significantly higher rates of movement (2.51 ± 0.37 m h^{-1}, n = 42) and oxygen consumption (0.035 ± 0.007 mg O_2 g^{-1} h^{-1}, n = 12) during the day than at night (0.52 ± 0.11 m h^{-1}, n = 35 and 0.025 ± 0.006 mg O_2 g^{-1} h^{-1}, n = 10; respectively). Ammonium concentrations in excreted water also were higher during the day (11.8 ± 2.1 µmolar, n = 18) than at night (4.3 ± 1.0 µmolar, n = 16) in *P. graeffei*. *H. edulis* demonstrated an opposite trend, with higher rates of movement (1.62 ± 0.29 m h^{-1}, n = 35) and oxygen consumption (0.046 mg O_2 g^{-1} h^{-1}, n = 8) at night compared to day (0.02 ± 0.01 m h^{-1}, n = 29 and 0.013 ± 0.002 mg O_2 g^{-1} h^{-1}, n = 9, respectively). Ammonium concentrations were higher at night (15.1 ± 3.2 µmolar, n = 12) than day (2.4 ± 0.5 µmolar, n = 9) in *H. edulis*. These findings indicate that tropical sea cucumbers have distinct species-specific diel cycles of activity, metabolism, and nutrient production.

Spawning behavior and development of *Bohadschia marmorata* var. *marmorata* (Holothuroidea: Aspidochirotida)

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Adults of the seagrass inhabiting sea cucumber *Bohadschia marmorata* var *marmorata* were induced to spawn and development of fertilized eggs was followed up to early juvenile phase. Adults climb along the side of the holding tank when ready to spawn. Males have intermittent to continuous release of sperms from the genital pore while females make forceful separate releases. Eggs (136–150 microns dia) are fertilized quickly and within 15 minutes, the vitelline membrane lifts. A 2-cell stage was observed 30 minutes after fertilization (AF) (Temp = 29°C; Sal = 33 ppt). Rotating coeloblastulae were observed less than 6 h AF. Gastrulae hatched within 11 h AF and swam upwards. These developed into early auiculariae (300–400 µm in length) in 26–34 h AF. Larval duration under culture condition was about two weeks during which the larvae were offered a mixed diet of microalgae. Larval development involved increased folding of the body margins, elaboration of the hydrocoel and elongation and separation of the left and right somatocoel. Late auriculariae with hyaline spheres appeared by Day 8 AF and larval size at this stage increased up to 650 to 880 µm in length. The lateral processes shrunk and the auricularia body shortened and transformed into a barrel shaped doliolaria (450–500 µm length) with 5 transverse ciliary bands around the levels of the hyaline spheres by Day 10 AF. The oral tentacles came out and the pentactula began to alternately attach and swim on Days 12–14 AF. With the addition of settlement cue on Day14 AF, swimming/searching pentactulae metamorphosed in the next 3 days. By Days 16–17 AF, most pentactulae have settled and developed a ventro-posterior podium, lost their swimming ability and became completely transformed into benthic juveniles that fed on benthic diatoms offered as early juvenile food. This information should be useful in developing the culture technology for this commercially valuable sea cucumber species aside from broadening our understanding of these parts of its life history.

Change of dermal ossicles during growth in some sea cucumbers of the genus *Holothuria* from the Colombian Caribbean Sea and Pacific Ocean

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The ossicles of the holothurians are the main character of taxonomic identification, but they can change in density, size and shape during growth, generating taxonomic problems to genus and species levels, mainly for juvenile specimens. In this work, these changes have been reviewed for three species of the *Holothuria* genus: *Holothuria (Cystipus) occidentalis*, *H. (C.) pseudofossor* and *H. (Selenkothuria) lubrica*, from the Colombian and Mexican Caribbean Sea and Pacific Ocean. In order to describe the changes in these species, small skin pieces from individuals of different size were observed. Ossicles were identified and their length, width and density were measured. It was found that the ossicles of the three species changed with growth, in length (decreasing or increasing), in width, in density, as well as in shape. On the basis of this description, identification of several juveniles of *H. (C.) occidentalis* was confirmed and the erroneous identification of some specimens from the Colombian Caribbean, like *H. (C.) pseudofossor* was corrected. Also, it was determined that the ossicle changes varied with geographical distribution and that the main variations were morphological.

Echinoderms of the Gulf of Mexico

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In "Echinodermata of the Gulf of Mexico" (Pawson, Vance, Messing, Solis-Marin, and Mah, in press, Texas A&M University), summary data are given for 512 species — including 38 new records — now known from the Gulf of Mexico. Information provided for each species included: author, date, habitat, depth range, geographic range, distribution in the Gulf of Mexico, and references. To supplement this summary, we are preparing a website on the Gulf of Mexico echinoderms. For each species, much new information will be provided on diagnostic characters, ecology, reproductive biology, taxonomic history and relevant literature. Color images of whole animals and, for about 50 species, digital video clips showing behavior, will be included, along with interactive illustrated keys to all taxa. In 2007, a prototype of this website will

be linked to the prototype of the new Smithsonian Institution/NOAA Oceans Web Portal, and the comprehensive version will appear when the completed Portal opens in 2008. We thank the Smithsonian Institution, and Dr Wes Tunnell and the Harte Foundation, Texas A&M University at Corpus Christi, for support, and Dominic Lee for his generous assistance.

Agents extracted from the body wall of the sea cucumber, *Cucumaria frondosa*, affect mutability in the tissues of other echinoderms as well

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Echinoderms share the ability to rapidly and reversibly alter the stiffness of their collagenous connective tissues. The mechanisms for this mutability are still largely mysterious, although a significant amount of work has been done on the body wall of the holothurian, *Cucumaria frondosa*, including chemical, genetic, and mechanical analyses. A current popular model suggests that stiffening and plasticizing agents are released from cells to interact with collagenous fibrils of the extracellular matrix, probably through intermediate, surface-associated glycoproteins. In league with this model, extracts of *C. frondosa* body wall have been shown to be mechano-effective on tissues from the same species. In this study, we demonstrate that other holothurians as well as echinoids, ophiuroids, and asteroids are all affected by these extracts, leading to questions of evolutionary conservation and homology with regard to mechanisms of mutability.

Status of our knowledge of the South African holothuroid echinoderms

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South Africa is a small landmass but with about 3000 km of coastline. The first record of a southern African holothuroid appeared in 1766. Since then there have been at first sporadic and then regular additions to the fauna. Currently about 132 nominal, 11 new species in the process of descriptions, and as many as 11 indeterminate species, constitute the fauna. Thus, approximately 154 species, spreading over 75 genera are known to occur, giving an approximate genus:species ratio of 1:2. Of the 132 nominal and 11 new species known, 89 are shallow-water forms, occurring in waters less than 100 meters deep, 52 species are deep-sea, extending to just over 3000 m in depth, and two are pelagic. Of the 89 shallow-water species, 31 (35%) species (including the tropicopolitan forms) constitute the Indo-West Pacific component, about 11 (12%) species, the West Indian Ocean component and the rest (47 species)(i.e. 53%) are endemics. If the West Indian Ocean component is added to the Indo-West Pacific component, the latter rises to about 47 %. Nearly all of the shallow-water Indo-Pacific species and about 21 of the endemics occur on the east coast, as far south as Port St Johns, the southern boundary of the subtropical province; about 25 endemics occur on the south coast from Port St Johns to Cape Point, the western boundary of the warm temperate province; and only 13 endemics occur on the west coast, north of Cape Point, the cold temperate province. Of the approximately 1400 species of holothuroids known to occur worldwide, South Africa is thus well endowed with about 11% of the world's holothuroid fauna.

Collection of Echinodermata from the Zoology Department, Institute of Biology, Federal University of Rio de Janeiro, Brazil: Asteroidea

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The collection of Echinodermata from the Department of Zoology at the Institute of Biology, Federal University of Rio de Janeiro (UFRJ) was initiated by Dr. Ignacio M. Brito in the 50's, and it has been increased over the years. This collection currently has over 3,400 lots including shallow water and deep-sea echinoderm species, from which 429 comprise asteroids. The asteroids have been classified into 11 families and identified as: Luidiidae[*Luidia alternata alternata* (n = 6), *Luidia clathrata* (n = 7), *Luidia ludwigi scotti* (n = 19), *Luidia senegalensis* (n = 9)]; Astropectinidae[*Astropecten brasiliensis* (n = 93), *Astropecten cingulatus* (n = 78), *Astropecten marginatus* (n = 76), *Astropecten* sp1 (n = 1), *Astropecten* sp2 (n = 1), *Plutonaster bifrons* (n = 378)]; Benthopectinidae[*Cheiraster (Cheiraster) sepitus* (n = 61)]; Asterinidae[*Asterina stellifera* (n = 69), *Asterina folium* (n = 20)]; Goniasteridae [*Ceramaster* sp1 (n = 42), *Nymphaster arenatus* (n = 405), *Pseudarchaster gracilis gracilis* (n = 30)]; Ophiasteridae [*Linckia guildingii* (n = 20)]; Oreasteridae [*Oreaster reticulatus* (n = 1)]; Echinasteridae [*Echinaster (Othilia) brasiliensis* (n = 87), *Echinaster (Othilia) echinophorus* (n = 14)]; Zoroasteridae [*Zoroaster fulgens* (n = 19)]; Asteriidae[*Coscinasterias tenuispina* (n = 118)]; Brisingidae[*Brisinga* sp1 (n = 1)].

So far this collection contains 36% of the asteroids species recorded for Brazil. Around 89% of the asteroids come from the Southeast, 3% from the South, and 1% from Northeast Brazil. Specimens collected in Argentina, Uruguay and Chile represent 7% of the deposited material. The asteroid collection information has been checked and re-organized so that it can be aggregated to Internet databases such as the Ocean Biogeographic Information System (OBIS). The Echinodermata collection is registered in the Brazilian Reference Centre on Environmental Information (CRIA) (http://www.cria.org.br/zoo/lista?action=show&id=ZOO1139453276). This work represents a contribution to the knowledge of the asteroids recorded for the Brazilian coast.

Brazilian Echinoderm Red List

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Nineteen of the 634 threatened species on the last Brazilian Red List (2004) are echinoderms (14 Asteroidea, 3 Echinoidea and 2 Holothuroidea). Most live in shallow water and are coveted by tourists and collectors. Some are extensively exploited for the curio trade (*Echinaster* spp, *Asterina stellifera*, *Narcissia trigonaria*, and *Eucidaris tribuloides*) and even for religious rites (*Oreaster reticulatus*). Species of the starfish genera *Astropecten* and *Luidia* are commonly caught as bycatch by dragging nets. The edible sea urchin *Paracentrotus gaimardi* and sea cucumber *Isostichopus badionotus* are threatened by the illegal collection for export to Asia and Europe. Knowledge of the biology of these species must precede any exploratory commercial enterprise. Endemic species like the viviparous *Synaptula secreta* (Holothuroidea) and the brooder *Cassidulus mitis* (Echinoidea) are threatened due to low dispersion capacity and restricted distribution. Starfishes like *Linckia guildingii* and *Coscinasterias tenuispina* are also heavily collected. They have a discontinuous distribution pattern and low population densities, many of which probably persist only by asexual reproduction. This reproductive strategy decreases the genetic variability and the gene flow among populations. Studies on the reproductive biology, population dynamics and genetics of the majority of the species are needed as well as on the taxonomy of those with high morphological variations, such as *Echinaster* and *Paracentrotus*. In order to achieve such knowledge, which depends on long term studies, it is essential to protect these species through governmental laws that restrict and control collection.

PIMRIS is a joint project of five international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the Secretariat of the Pacific Community (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific (USP), the South Pacific Applied Geoscience Commission (SOPAC), and the Pacific Regional Environment Programme (SPREP). This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ("grey literature"); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

PIMRIS

Pacific Islands Marine Resources Information System

Status of the sea cucumber fishery in the Sultanate of Oman

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Abstract

Sea cucumber harvesting in Oman constitutes a minor fishery. Harvesting takes place in Mahout Bay and centers on the sandfish, *Holothuria scabra*. The sea cucumber fishery was revived in 2003 with the increased demand of beche-de-mer from international markets. Sandfish are collected by hand by walking in shallow-water areas during low tide, between late November and May. Sandfish are traditionally processed to a dried form after first gutting, boiling and cleaning. While local prices paid to collectors varies from 10–50 Omani rials (OMR)[2] for 100 live specimens, depending on the size of the sea cucumber and the season, local traders receive OMR 35–55 per kg of dried sandfish (beche-de-mer) when they export their product. Almost all Omani beche-de-mer are exported to the United Arab Emirates (UAE) for re-export to international markets.

Introduction

Very few studies have been conducted on sea cucumber harvesting and management in Oman (Johnson 1990). The primary species harvested in Oman is the sandfish, *Holothuria scabra* (*feik albahar* in the local language, which means "sea jaw"). Men involved in this fishery perform a wide range of other income-generating activities and 50% of the fishers are women. Mahout Bay, which is in the Gulf of Masira in the Arabian Sea, is the main area of sea cucumber harvesting in Oman. *H. scabra* is considered to be the most valuable species for beche-de-mer production (Conand 1990, 2004) and the most widely harvested in the tropics (James 2001). Information on the status of this Omani fishery was obtained through a questionnaire developed by the authors of this paper. Sea cucumber fishing in Mahout Bay began in the 1960s, when Mahout Island was a small traditional port used to transport goods to and from East Africa and India; the islanders used to collect sea cucumbers and exchange them for food stuffs from abroad. The fishery was discontinued in the 1970s because the port was no longer operating. However, the sea cucumber fishery was revived in 2003 due to an influx of foreign traders from UAE and subsequent intensive fishing during 2004 and 2005. The fishery now is unregulated with open access to anyone. This paper describes the status of the existing fishery and resource, and provides management recommendations.

Methodology

A preliminary survey of sea cucumbers was carried out during September and October 2005, in Mahout Bay. Information on the species exploited, fishing techniques, processing and trading was obtained through direct field observations and through a questionnaire that was given during interviews with sea cucumber fishers, processors, traders and local authorities around the Mahout area. More than 30 people, including women and traders answered the questionnaire.

Results and discussion

The fishery

The existing sea cucumber fishery in Oman centers on a single species, *Holothuria scabra* (Fig. 1). This species exists only on the eastern side of Mahout Bay and in limited areas, such as sea grass beds with fine sand in sheltered flats and lagoons.

Sea cucumbers are harvested by hand during low tide, and mainly during spring low tides. There are six main *H. scabra* fishing grounds in Oman: Al-Eigah, Wadsumah, Al-Naqel, Al-Shaghia, Al-Hofnat and Ras-Knasah (Fig. 2). The first three fishing grounds are sandy islets exposed during spring low tides, while the other fishing grounds include other coastal areas and lagoons. To reach the sandy islets during spring low tides, collectors

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2. 1 (Oman rial) OMR=26 USD

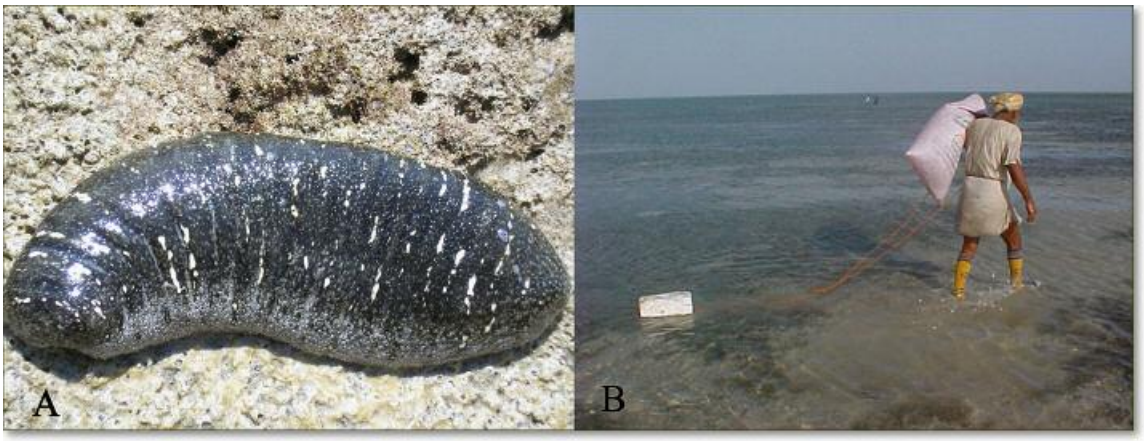

Figure 1.
(a) ***Holothuria scabra*** **is currently the only exploitable sea cucumber species in Oman.**
(b) ***H. scabra*** **being collected at low tide in Al-Eigah, Mahout Bay.**

use motorized boats that generally belong to the traders. Traders often contract groups of collectors, mostly women, in order to buy their sea cucumber harvests, providing them with free services such as transportation (boats or vehicles), drivers, dive masks and food.

About three boats, each owned by four major traders, are used in fishing operations. Each boat has 7–10 collectors on board, and may make two round trips in one day with 10 collectors in each trip. It takes around 15–60 minutes to reach the fishing grounds. Fishers work individually and collect and store sea cucumbers separately from other fishers' catches in large flour bags or plastic buckets (Fig. 1). Free diving (mask only) is only done infrequently, and is restricted to men.

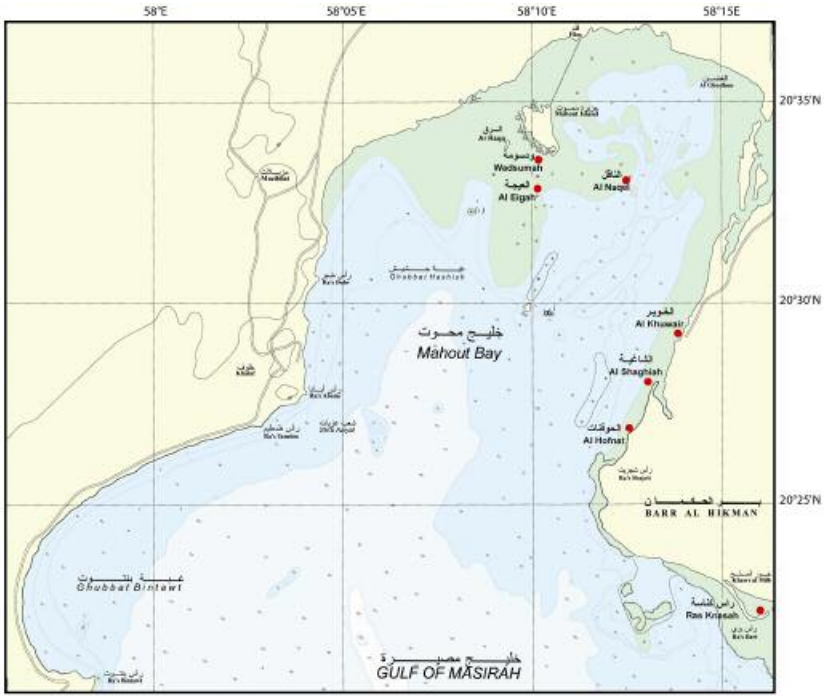

Figure 2. Mahout Bay in the Gulf of Masirah. Red spots indicate the main sandfish fishing areas.

The number of monthly fishing days per season per fisher is estimated to vary from 10 to 20. The estimated number of fishers per season was 100 in 2004 and 200 in early 2005, indicating an increase in demand for beche-de-mer and resulting in a high income for the fishers and traders. The average fishing hours per fisher per working day is three to four hours with an average collection of 100 live sandfish per fishing trip. Among the collectors, women represent the largest group, about 50%, while men and children account for 30% and 20%, respectively.

The sea cucumber fishery is linked with the shrimp fishing season, which runs from September to March. Sea cucumber fishing begins when the number of shrimp landed decreases. This occurs in late

Figure 3. Steps for processing *H. scabra* in Oman, Mahout area.

November. The primary reason for low landings of shrimp in November is the migration of shrimp at this time to deeper waters for spawning. And because fishermen use only traditional cast nets to catch the shrimp, once the shrimp go to deeper waters the fishermen are no longer able to catch them. Therefore, in November, fishers begin collecting sea cucumbers. When the shrimp fishing season ends, sandfish harvesting begins. Sea cucumber harvesting begins in late November, reaching its peak between January and March, and then gradually decreasing through to May. The shrimp fishing season is related to the socioeconomic traditions of the Mahout communities as well as sea conditions. Because most Mahout communities are Bedouins, they seasonally move out of Mahout to adjacent areas, particularly during the summer months (June–August) when sea conditions are too rough for fishing due to the southwest monsoon.

Processing

The processing of sea cucumber is done by the traders, and the process in Oman involves gutting, boiling, preserving, cleaning and drying (Conand 1999) (Fig. 3).

Gutting

Once the sea cucumber is harvested, the body is immediately shaken and squeezed to extract the gut through the anus. However, some fishers make a 3-cm-long slit from the mouth to the anus, and squeeze the body to remove the gut.

First cooking

Prior to boiling, the sea cucumbers are sorted by size and then boiled in seawater with extra salt added. Cooking time is about 1–1.5 hours. This step softens the meat, kills microorganisms, contracts the sea cucumber to the desirable body size, and reduces the water in the tissues, thereby speeding up the drying process.

Preserving and storing

In order to facilitate the removal of the outer skin, which contains tiny calcareous spicules, the body wall is stored indoors in a covered barrel for 24–30 hours to smoothen the outer layer of the body wall. Another method used to achieve this step is to bury the cooked sea cucumbers in the sand for 24 hours. Both methods are done at the processing sites.

Cleaning

Cleaning involves scraping the outer body wall with a knife or brush to remove the chalky particles in the surface wall.

Second cooking

The second cooking is similar to the first cooking, except it is for less time (< 40 min), to eliminate and odors and residues.

First drying

The cooked sea cucumbers are kept indoors for four to five days so that dust and sand do not get on them and so that they become semi-solid. Rice sacks are placed under the processed sea cucumber to absorb moisture and wetness.

Second drying

The sea cucumbers are left outdoors under the sun for final drying and solidifying. The beche-de-mer are then ready for marketing.

Trade

Prices paid by local traders to collectors vary, depending on the size of the sea cucumbers and the season[3]. However, the average price paid between 2000 and 2004 was roughly OMR 10 per 100 live sea cucumbers. From January to March 2005, the price increased to OMR 45–50 for 100 live sea cucumbers, with an average price of OMR 30. This can be attributed to the high demand for this species and the low supply from major beche-de-mer producing countries because of overfishing (Uthicke and Conand 2005). All fishing and processing expenditures for the fishery in Oman (e.g. transportation, fuel, dive masks, cooking gas, salt and generator are paid for by the traders (Table 1).

Table 1. Expenditures paid by beche-de-mer traders for the sea cucumber fishery.

Expenditures / day	Cost (OMR)
Hired boat	10
Boat fuel	5
Cooking gas	3
Salt	2
Total	20

Once the beche-de-mer are processed, they are stored unsorted in a warehouse. Two or three days before loading, the beche-de-mer are sorted into different sizes and packed in polypropylene bags. Presently, four major local traders are actively involved in marketing beche-de-mer.

Although Oman is a beche-de-mer producing and exporting country, it still remains relatively unknown to most international markets. Beche-de-mer from Oman are mainly exported to UAE, and to a lesser extent, Hong Kong. The major Omani sea cucumber traders have agents in UAE for purchasing the product. Prior to fishing season, the agents visit the area to give the traders processing instructions and to negotiate the price. The price paid by the agents varies between OMR 35 and 55 per kg (dry weight), depending on size and quality.

Although Oman has been harvesting and processing sea cucumber since 1995, the Directorate of Statistics groups sea cucumber production with "unidentified fish". Yet, from December 2004 to June 2005, about 1.2 tonnes of frozen sea cucumbers were documented as having been exported to UAE (Directorate of Fisheries statistics, pers. comm.). Similarly, the Directorate of Fisheries at Mahout permitted one trader to harvest and process 250, 150 and 300 kg of dried sea cucumbers during January, May and June 2005, respectively. Because this is a minor and relatively new fishery, in term of fetching high prices, the ministry of Agriculture and Fisheries does not care of it. Fish inspectors at the border check post are not familiar with or do not recognize sea cucumbers, especially dried ones, and so the product passes through the border without identification. Some sea cucumber traders do occasionally register their product at the Directory of Alwusta region, where sea cucumbers are present. But communications within these channels are sometimes missed. Therefore, we are working hard to strengthen communications. There is cooperation in the collection of fisheries data among fisheries organizations, but this does not include sea cucumbers. Starting from this year and based on our study the data will be collected.

Although UAE is the main importer of Omani beche-de-mer, Hong Kong has recently (2000 and 2001) begun importing Oman's beche-de-mer products (Bruckner et al. 2003), although in lower quantities than what UAE imports (Table 2). Oman production rarely appears in international beche-de-mer statistics, which may be because only small quantities are exported directly to international markets, and Omani beche-de-mer production is limited to UAE markets.

Table 2. Imports of sea cucumber into Hong Kong (after Bruckner et al. 2003; Ferdouse 2004).

Year	Oman		UAE	
	Quantity (t)	Value (USD'000)*	Quantity (t)	Value (USD'000)
1996			3.00	19
1997			22.00	70
2000	0.96	14.25	10.85	161
2001	0.49	7.26	40.62	602

* Estimated values based on UAE values during the same period

Issues and recommendations for the management of the *H. scabra* fishery in Oman

At present, sea cucumber fishing in Oman is not regulated, due in great part to a lack of understanding about the biology and ecology of Omani sandfish resources.

Despite the fact there are no direct regulations to manage sea cucumber resources, a few general

3. At the beginning of the sea cucumber fishing season, competition among traders is low, but is high among fishers. So, the sandfish fishing amount per fisher is high but the price is low. At this time, negotiation between local traders and exporters (or foreign traders) takes place. The high price is often gained in December and January, when the demand is high and competition among traders occurs.

fishery management restrictions are practiced in the region, such as restrictions on harvesting any kind of marine resource use scuba. Sea cucumber harvesting is mainly restricted to collection by hand while walking during low tide or by free diving. Although there is no specific closed season for sea cucumber harvesting, fishers usually collect them for six months, from November to May, with peak harvesting occurring from January to March. Harvesting in the area is historically restricted only to Mahout traditional fishers; there is no commercial fishery and fishers from neighboring areas are not allowed to collect sea cucumbers

From the above description of the fishery coupled with the walk survey using transect (Khalfan 2005), several management issues have been identified by this study.

1. There is a lack of information on landings, catch per unit of effort, densities, and processed production of *H. scabra* from Oman, and action should be taken to begin collecting this information.
2. The Directorate of Fisheries at Al-Wusta (Central) Region should be made responsible for collecting the above data by providing local traders with export permission certificates that indicate the name of the trader, age of trader, area of the trader, form of product (dried, frozen, live or salted), quantity of the product, origin of the product, country/area to which the product will be exported, name of border/check post/sea port, date of permission etc.
3. Fish inspectors at borders should be made familiar with sea cucumbers, both in their live and dried form. This will facilitate the Directorate of Fisheries Statistics to group sea cucumber data separately in the annual statistical book.
4. Research in various aspects of biology, ecology, stock assessment and enhancement, and marketing must be initiated. Reproductive biology and size at first maturity are required in order to establish regulations. The exploration of new fishing grounds and the designation of marine protected areas (MPA) in some remote sea cucumber sites are also needed to minimize fishing pressure and to protect brooders, respectively. The marketing structure should be studied to develop an understanding of the socioeconomic aspects of this fishery. The initiation of feasibility studies on sandfish aquaculture in Oman is essential as it is the quickest and most stable solution for meeting export demands and ensuring natural stock enhancement.
5. Capacity building programmes — training, study tours, participation in national and international meetings and workshops on sea cucumbers — should be conducted and supported by government organisations.

Acknowledgements

This project was funded by Oman Fisheries Company (OFC). We are grateful to Dr Ahmed Al-Hosni, Director General of Fisheries Research and Extension and Mr Saeed Al-Rawahi, Deputy General Manager (OFC) for their special interest and continuous encouragement throughout the project. Special thanks are due to Drs. Chantal Conand and N. Jayablan for critically reviewing this paper. Their numerous comments and suggestions aided considerably in improving the manuscript. Appreciation is also extended to all staff of the Marine Science and Fisheries Center for their assistance and encouragement.

References

Bruckner A.W., Johnson K.A. and Field J.D. 2003. Conservation strategies for sea cucumbers: Can a CITES Appendix II listing promote sustainable international trade? SPC Beche-de-mer Information Bulletin 18:24–33.

Conand C. 1990. The fishery resources of Pacific island countries. Part 2: Holothurians. FAO Fisheries Technical Paper, no 272.2.143 p.

Conand C. 2004. Present status of world sea cucumber resources and utilization: An international overview. p. 13–23. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.-F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper No. 463. 425 p.

Ferdouse F. 2004. World markets and trade flows of sea cucumber / beche-de-mer. p. 101–117.In: Advances in sea cucumber aquaculture and management. Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.-F. and Mercier A. (eds). FAO Fisheries Technical Paper No. 463. 425 p

James D.B. 2001. Twenty sea cucumbers from seas around India. Naga, the ICLARM Quartery 24(1&2):4–8.

Johnson D. 1990. Shellfish/demersal final report. Oman Marine Science and Fisheries Center. Omani-American Joint Commission. Project No. 272-0101-1. 34 p.

Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.-F. and Mercier A. (eds). 2004. Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper No. 463. 425 p.

Al-Rashdi K. 2005. Project final report on preliminary survey of sea cucumber resource in Oman, Mahout Bay. Marine Science and Fisheries Center. p 29–49.

Uthicke S. and Conand C. 2005. Local examples of beche-de-mer overfishing: An initial summary and request for information. SPC Beche-de-mer Information Bulletin 21:9–14.

A framework for addressing socioeconomic and management aspects of sea cucumber resources in the western Indian Ocean

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Summary

This paper reveals how the socioeconomic and management objectives of a three-year sea cucumber project in the western Indian Ocean (WIO) (cf. Conand et al. 2006) will be addressed. A conceptual model of sea cucumber resource dynamics is presented. This model encompasses multiple levels and considers the main structures of the sea cucumber fishery such as fishing and collection grounds, resource users and other stakeholders involved in the fishery (e.g. fishers, middlemen and importers), the links between stakeholders, villages and countries, and the associated management initiatives at different levels. This framework is promising when analyzing the sea cucumber fishery from a holistic perspective, considering both social and ecological interactions. The results of the study will provide knowledge and management advice for the sustainability of the sea cucumber fishery in the WIO; however, the framework is not restricted to the WIO, and may be adapted to other fisheries.

Introduction

Sea cucumbers have always been an important resource in the coastal areas of the western Indian Ocean (WIO). Historical reports illustrate the commercial importance of sea cucumbers through narratives of complex routes of export from the WIO to China and probably other destinations in Asia (Gilbert 2004). Beche-de-mer or bicho-do-mar (sea slug) is the name used for sea cucumbers in the Pacific Islands, and refers to the name used by the original merchants of the triangular trade. Goods from Europe were exchanged for sea cucumbers, which were traded again in China for tea and spices (Conand 1989, 1990, 2001). Probably the expression of the merchants "We are looking for beche-de-mer" was common and gave birth to the common name for holothurians used currently. At present, sea cucumbers still constitute an important resource in the region, although the understanding of their biology, ecology, socioeconomic importance, and associated management initiatives is poor (Conand et al. 2006).

The WIO region — which extends along the east African coast from Somalia to South Africa and includes the island states of Mauritius, Comoros, Seychelles, Reunion and Madagascar — has numerous rural populations that are mainly dependent on marine resources for subsistence and commerce. Although sea cucumbers are not consumed by the local communities, they are still one of the most highly priced fisheries products (Department of Fisheries and Marine Resources Zanzibar, Tanzania, pers.comm.). The resource is widespread along the complex, 12,000-km-long coastline of the WIO. The number of species is high — about 106 — with at least 20 species being commercially valuable (Clark and Rowe 1971; Conand 1999).

This paper presents the generalities of a newly developed framework to analyze the socioeconomic and management aspects of sea cucumbers in the WIO. It is linked to the article by Conand et al. (2006), in which a general description of a larger three-year project analyzing sea cucumber resources in the WIO is presented. Here, we focus on the particular objectives dealing with the project's socioeconomic and management issues, referred to as objectives 4 and 5 in the article by Conand et al. (2006).

Understanding sea cucumbers as a resource: Premises and approaches

The main premise of the sea cucumber project in the WIO is that "successful management cannot be

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achieved without key ecological and socioeconomic information" (Conand et al. 2006). In general, three levels of analysis and understanding are needed for the achievement of successful management that will maintain productive ecosystems.

1) Knowledge about the ecology of the system, including structures (e.g. species, ecosystems, etc.) and their dynamics (e.g. processes, succession, resilience, disturbance regimes, etc.);
2) Knowledge about management systems currently in effect and the efficiency of feedback systems in monitoring; and
3) Consideration of the governance structures framing resource use in which local users and civil society are considered (Berkes and Folke 1998).

Point 1 will be addressed by the three-year project (Conand et al. 2006), but points two and three are directly related to the economic, social and management issues, and an overview of how to handle these issues will also be presented.

The importance of temporal and spatial scales

Socioecological problems cannot be treated in isolation. Cross-scale interactions in both temporal and spatial terms are crucial to the understanding of resource use dynamics (e.g. Holling 1973, 1992; Levin 2000; Berkes and Folke 1998; Young 2002). Scale should be considered in order to understand the complexity of interrelated economic, ecological and social systems (Holling 2001). Management and institutional arrangements are more likely to succeed if they work at the correct scale, in accordance with the ecological scale (e.g. spatial, temporal and functional; Lee 1993) and ecological processes (e.g. Christensen et al. 1996). There are, however, common mismatches between institutions and scales, both temporally and spatially, which produces management failures. Mismatches between institutions themselves have been identified as fundamental recently (de la Torre-Castro 2006; de la Torre-Castro and Lindström in prep.). The importance of scales has been illustrated in the WIO region for different coastal systems. In Tanzania, for example, studies on resource use dynamics (fisheries and seaweed farming) addressing the local scale of Chwaka Bay with cross links to Zanzibar and Tanzania mainland (de la Torre-Castro 2006, 2006a), on local involvement of women in shellfish production (N.S. Jiddawi, Institute of Marine Sciences, Zanzibar Tanzania, pers. comm.), and resource dynamics and marine protected areas (MPAs) in Mafia Island (I. Bryceson, Norwegian University of Life Sciences, UMB Norway, pers. comm.). In Kenya, studies on the changes in fisheries practices in four villages on the south coast (Ochiewo 2004), baseline socioeconomic studies in northern Kenya (Cinner and McClanahan 2006), and mangrove fisheries in Gazi Bay (Crona 2006), have also been completed. At larger scales, the WIO has been historically linked to global scales through commercial routes involving the trade of a large variety of commodities in which probably sea cucumbers played an important role. Our conceptual model for the analysis of sea cucumber resources in the WIO considers cross-scale interactions from local to global levels and is presented in subsequent sections (see also Fig. 1).

Socioeconomic and management specific objectives

The specific objectives of the socioeconomic and management components are defined in Conand et al. (2006).

Socioeconomic objective

"To determine the national marine resource use patterns, the social and economic characteristics of the fisher communities and the contribution of sea cucumbers to the national economies and local livelihoods of the coastal areas."

Management objective

"To analyze the management systems present in the area. To gain knowledge and synthesize information about the general management efforts and strategies including monitoring, licensing, control, statistical catch collection, general policies, establishment of MPAs, resource perception, etc. The target organizations will be governmental agencies that are concerned with management of fisheries and marine protected areas, in order to understand the existing fisheries management regimes and establish the existing constraints, opportunities and/or challenges faced by these regimes."

The objectives of the socioeconomic component of the sea cucumber project can be expressed in two main research lines: 1) livelihood and local importance of the sea cucumber fishery (objective 4), and 2) formal management associated with the different levels and agents of the sea cucumber fishery (objective 5). Some of the most important aspects considered in the investigation will be to address the livelihood component, including the socioeconomic characteristics of the local coastal communities dealing with the sea cucumber fishery. The focus will be on the sea cucumber collectors and middlemen. Questions such as: Who are the sea cucumber fishers? What is the contribution of this fishery to local communities and particular households? What is the role of the sea cucumber fishery in livelihood diversification and benefits? What is the division of labour? What are the subsistence and commercial components of the fishery? What are the most important fishing

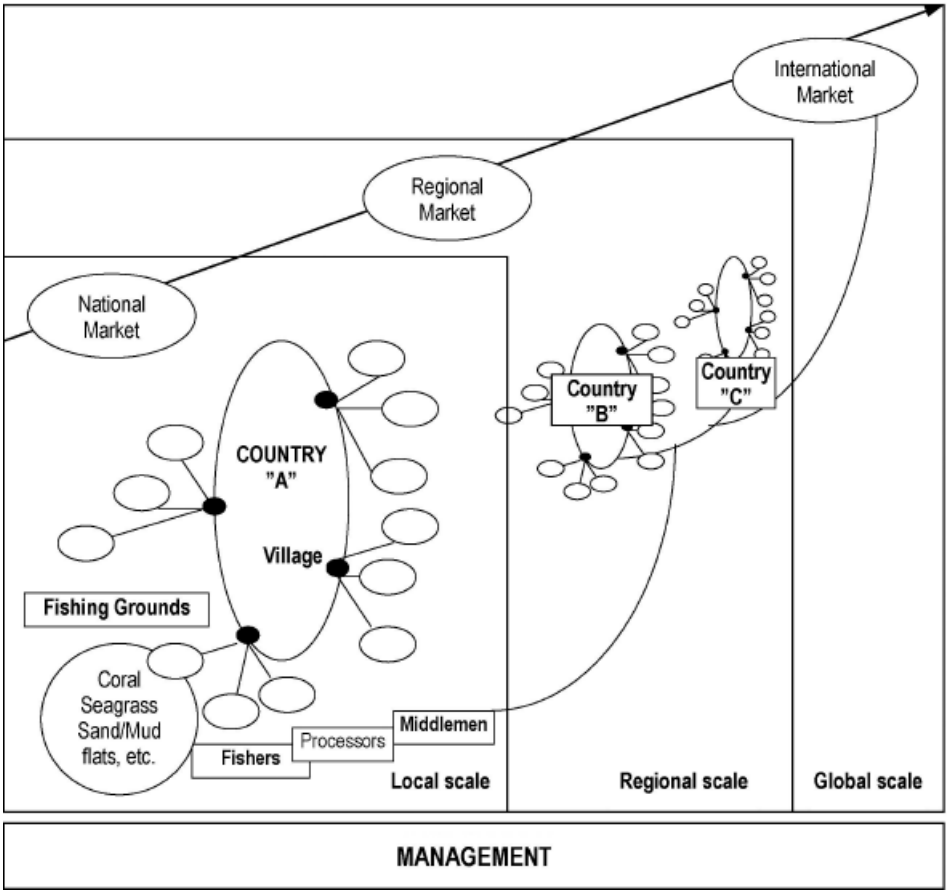

Figure 1. Conceptual model for the socioeconomic analysis of sea cucumber resources in the western Indian Ocean.

grounds and what are the most valuable species? Moreover, what is the relationship between sea cucumber fishers and middlemen? What is the adaptive capacity of sea cucumber fishers? And how resilient is the resource?

The project will also address formal management (i.e. management structures and initiatives in government agencies), and the following aspects will be covered: type of licensing system, monitoring systems, basic statistical information (weight and value), consideration of the differences in species, methods of statistical capture, the existence of a specific policy for sea cucumber fisheries, communication with local communities involved in sea cucumber fishery, perception of the problems of the sea cucumber fishery, and the level of commitment of fisheries managers.

Grasping the big picture: Conceptual model for the analysis of sea cucumber resources in the WIO

The conceptual model for sea cucumber resource analysis is presented in Figure 1. The model shows the basic elements of sea cucumber resource use and the possible links between them. The model can be seen as a global network: from a local scale level of productive ecosystems in nearby villages, to a global scale level in which the ecosystem goods reach international markets. The basic idea of the conceptual model is also linked to commodity chain analysis approaches (e.g. Gibbon and Ponte 2005), which in simple terms can be understood as following the whole production chain of the product — from local ecosystems to international markets. Local fishing grounds are found in different ecosystems, such as seagrass beds, coral reefs, and sand or mud flats. The main stakeholders are sea cucumber fishers, middlemen, and the companies buying the product. Regional links between producing countries may be present as well. The project will be working in different countries and sites (e.g. Kenya, Tanzania mainland, Tanzania/Zanzibar, Madagascar, and Seychelles), and this conceptual model will be used to organize and guide the regional and global analysis.

Selected study sites

In each country, specific study sites will be selected (Fig. 2). The sampling design will consider protected and non-protected sites in each place. The

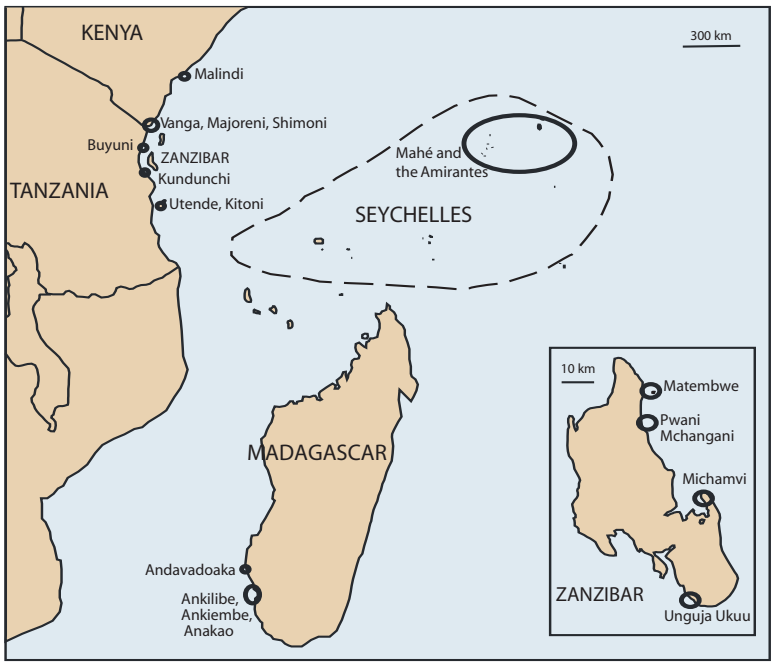

Figure 2. Selected study sites for socioeconomic studies of sea cucumber resources in the western Indian Ocean.

preliminary selected pilot study sites are shown below; however, it is possible that the conditions and/or production have changed and new sites will be considered in that case.

Tanzania mainland and Zanzibar

In Tanzania mainland, four sites have been identified: Kunduchi, Kitoni, Buyuni, and Utende. Kunduchi represents a heavily exploited site; Kitoni is a protected site, inside a marine park area. Buyuni in Dar es Salaam is where the collection of sea cucumbers has recently begun, and is growing in popularity. Utende is a protected site, located in a marine park, and will be considered if time and resources are available.

In Zanzibar, four sites have been identified: Pwani Mchangani, the village of Matemwe close to Mnemba Island, Michamvi and Unguja Ukuu. Pwani Mchangani has been an area of heavy exploitation, whereas Mnemba Island is a protected area. Unguja Ukuu in the south is where an active fishery is occurring, and Michamvi has been reported as a productive fishing ground. The island of Misali close to Pemba is a good candidate representing an almost non-exploited area.

Kenya

Four pilot study sites have been dentified in Kenya: Vanga, Shimoni, Majoreni, and Malindi. Vanga is a village with high exploitation levels. Shimoni is a protected site next to a marine park. At Majoreni, sea cucumbers are now fished following finfish exploitation. Malindi is closer to the marine park and will be considered if time and resources are available.

Seychelles

Sea cucumbers are widely fished in coastal and deeper waters, with fishing effort mainly in the 15–40 m depth range. Due to the large size of Seychelles' EEZ, stock surveys focused on the Mahe Plateau and the Amirantes. Sites within the boundaries of marine parks were also surveyed on the Mahe Plateau, and will thus permit a comparison between protected and non-protected areas.

Madagascar

Andavadoaka, located 150 km north of Tulear, is representative of a site involved in the establishment of an MPA. Ankiembe and Ankilibe are the two fishing villages of Tulear Bay. Ankiembe is located in Tulear District, while Ankilibe is located about 13 km south of Tulear. Both villages are settled by Vezo fishermen. Anakao is about 50 km south of Tulear. A part of the reef is a village MPA devoted to ecotourism.

In general, the sites overlap with the sites for other biological and ecological studies of the same larger project (Conand et al. 2006).

Methods and targeted categories

Data about socioeconomics, resource users, and formal management structures will be gathered using five different methods. Three main stakeholders' categories will be targeted. The table below shows the interview sampling design and associated methods. The methods will apply to protected and non-protected areas so that differences will be identified and the role of MPAs in sea cucumber fisheries can be evaluated.

The selected methods are:

Questionnaires: A structured questionnaire will be administered to a selected sample of respondents to obtain quantitative data that can be statistically analysed. Respondents will be selected randomly from among the sea cucumber fishers and middlemen.

Semi-structured interviews: The approach proposed by Bunce et al. (2000) will be applied. Respondents will be randomly selected and will include sea cucumber fishers and middlemen. Semi-structured interviews will be conducted using interview guides/semi-structured questionnaires with open-ended questions (see also Kvale 1996). Some respondents will be interviewed in their homes while others will be interviewed at the beach where they land their fish or conduct their business. While appointments will be made for interviews to be conducted at a time that is convenient to respondents, some interviews will be conducted on the spot. Using this method, it will be possible to probe for answers, follow up on original questions, and pursue new lines of questions. It will create room for a two-way interaction and exchange of information between the interviewer and the respondent.

Key informants interviews: The key-informant interview technique expounded by Bunce et al. (2000) will be used to extract information from the opinion leaders. These key informants (opinion leaders) will be people who hold some respected positions in the society. The snowball method (let locals point out key informants) will be used to identify key informants in the villages. Key informants will give insight into many issues that need further clarification and will help in the validation of information collected using the other research methods.

Focus group discussions: The approach proposed by Bunce et al. (2000) will be used in this study. A set of open-ended questions will be used to prompt participants into free discussions focusing on the issues under the study. The focus group interviews will be arranged in advance and respondents will decide on their preferred venue for the meetings. The focal groups will consist of 5 to 10 people. Using this method, it will be possible to probe for answers, while still following up on original research questions. This method also encourages interactions between respondents and interviewers.

Network analysis: Ecological networks (e.g. food webs, species dynamics, etc.) are of crucial importance. All interactions between species can be visualized as ecological networks (e.g. Montoya et al. 2006) and their importance in natural resource management has been recently illuminated (Bodin 2006; Janssen et al. 2006). The proposed conceptual model — which considers the interactions between stakeholders, ecosystems, villages, countries and the sea cucumber — can be seen as a network. This model will be used predominantly as a conceptual tool to illuminate the scales, links and nodes from the local fishing/collection grounds to importing countries of sea cucumbers. Social networks, their structural characteristics, and how they are formed are relevant for natural resource management (e.g. Tompkins and Adger 2004; Newman and Dale 2005; Bodin 2006; Bodin et al. 2006). Trust building and communication may enhance management, and networks across scales may increase ecosystem resilience (e.g. Tompkins and Adger 2004). However, networks may also be detrimental for management, for example forming much-closed groups leading to isolation and exclusion of external inputs and communication. A dynamic balance between internal (bonding) links and external (reaching) links is needed (Newman and Dale 2005). In the case of sea cucumber fisheries, the network structure is a helpful tool for identifying the number of links between elements of the fisheries (e.g. ecosystems, villages, fishers and nations), the distances and links between different places and stakeholders, and the degree of modularity or cluster formation between stakeholders associated with sea cucumber fisheries. The amount of links reaching outside single villages (bridging links) and the internal community or stakeholders' links (bonding links) are important indicators (Newman and Dale 2005). The basic idea is to work with a conceptual tool that brings all the elements and scales of sea cucumber fisheries together to better understand the dynamics. Questions such as: What is the global extension of the sea cucumber activity? How far does the activity reach? How are stakeholders grouped in the producing countries? How do elements structurally relate to each other? may be answered with the help of the model.

Regional coordination and working plans

The socioeconomic and management components are part of the larger three-year project financed by

the Western Indian Ocean Marine Science Association (WIOMSA), which focuses on Kenya, Tanzania, Madagascar, Reunion and Seychelles. Within each country, one researcher is responsible for the socioeconomic and management components. Regional coordination is maintained through workshops, parallel data collection with harmonized methods (questionnaires and interview forms), and weekly electronic communication. Once the data are collected, the team will gather and analyze the national level information and proceed to the regional synthesis, with links to global markets, in a workshop. Planning, data collection, analysis and writing will take approximately two years.

Conclusion

The proposed model (which considers multiple scales), the variety of ecosystems involved, the diversity of stakeholders, and the various management systems seem to be promising for a broader understanding of the state of the art of sea cucumbers fisheries in the WIO. The model and approach is intimately linked with the larger three-year project (Conand et al. 2006), and the overall results will provide information about sea cucumber fishery dynamics and future management strategies. The model can also be used for other fisheries and is not restricted to the WIO.

Acknowledgements

We are thankful to WIOMSA/MASMA (Marine Science for Management) for financing this project and to the University of Dar es Salaam for hosting the initial planning workshop. The Kenya Marine and Fisheries Research Institute (KMFRI) facilitated transactions and the Department of Systems Ecology at Stockholm University provided inputs on this manuscript. Thanks to Lars Lindström, Nils Kautsky, Nyawira Muthiga and Chantal Conand for valuable comments.

References

Berkes F. and Folke C. (eds). 1998. Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge: Cambridge University Press. 459 p.

Bodin Ö. 2006. A network perspective on ecosystems, societies and natural resource management [dissertation]. Stockholm: Stockholm University. 42 p.

Bodin Ö., Crona B. and Ernstson H. 2006. Social networks in natural resource management: What is there to learn from a structural perspective? Ecology and Society 11(2): r2. [also available at: http://www.ecologyandsociety.org/vol11/iss2/resp2/]

Bunce L., Townsley P., Pomeroy R. and Pollnac R. 2000. Socioeconomic manual for coral reef management. Australian Institute of Marine Science. Townsville, Australia. 251 p.

Cinner J. and McClanahan, T.R. 2006. A baseline socioeconomic assessment of fishing communities along the north coast of Kenya. Wildlife Conservation Society's Coral Reef Conservation Project, Mombasa (Kenya) and the Western Indian Ocean Marine Science Association (WIOMSA). [Also available at: http://www.wiomsa.org]

Christensen N.L., Bartuska A.M., Brown J.H., Carpenter S., D'Antonio C., Francis R., Franklin J. F., MacMahon J.A., Noss R.F., Parsons D.J., Peterson C.H., Turner M.G., and Woodmansee R.G. 1996. The report of the Ecological Society of America Committee on the scientific basis for ecosystem management. Ecological Applications 6:665–691.

Table 1. Methods and categories to be targeted in the socioeconomic studies of sea cucumber resources in the western Indian Ocean.

Method/categories	Fishers	Middlemen	Management authorities
Questionnaires	yes	yes	no
Semi-structured interviews (topics included in the questionnaires)	yes	yes	yes
Key informants interviews – Snowball method in the villages (let the locals point out key informants)	yes	yes	no
Focus groups discussions	yes	no	no
Network analysis		Cross cutting	

Clark A.M. and Rowe F.W.E. 1971. Monograph of the shallow-water Indo-West Pacific echinoderms. Bath, England: Pitman Press.

Conand C. 1989. Les Holothuries Aspidochirotes du lagon de Nouvelle-Calédonie : biologie, écologie et exploitation. Etudes et Thèses, ORSTROM., Paris : 393 p.

Conand C. 1990. The fishery resources of Pacific island countries. Part 2: Holothurians. FAO. Fisheries Technical Paper, no. 272.2 : 143 p.

Conand C. 1999. Manuel de qualité des holothuries commerciales du Sud-Ouest de l'Océan Indien. Commission Océan Indien : 39p.

Conand C. 2001. Overview of sea cucumbers fisheries over the last decade: What possibilities for a durable management? p. 339–344. In: Barker M. (ed) Echinoderms 2000. Lisse, Netherlands: Swets and Zeitlinger.

Conand C., Muthiga N., Aumeeruddy R., de la Torre-Castro M., Frouin P., Mgaya Y., Mirault E., Ochiewo J. and Rasolofonirina R. 2006. A three-year project on sea cucumbers in the southwestern Indian Ocean: National and regional analyses to improve management. SPC Beche-de-mer Information Bulletin 23:11–15. [Also available at: http://www.spc.int/coastfish/News/BDM/23/BDM23-Conand.pdf]

Crona B. 2006. Of mangroves and middlemen. A study of social and ecological linkages in a coastal community [dissertation]. Stockholm: Stockholm University. 37 p.

De la Torre-Castro M. 2006a. Humans and seagrasses in East Africa: A social-ecological systems approach [dissertation]. Stockholm: Stockholm University. 62 p. [Also available at: http://www.diva-portal.org/diva/getDocument?urn_nbn_se_su_diva-1061-2__fulltext.pdf]

De la Torre-Castro M. 2006b. Beyond regulations in fisheries management: The dilemmas of the "beach recorders" bwana dikos in Zanzibar, Tanzania. In press Ecology and Society. [Also available at: http://www.ecologyandsociety.org]

De la Torre-Castro M. and Lindström L. (in prep.) Fishing for institutions — the institutionalization of the social-ecological web in Chwaka Bay, Zanzibar. (manuscript).

Gibbon P. and Ponte S. 2005. Trading down: Africa, value chains and the global economy. Philadelphia: Temple University Press. 272 p.

Gilbert E. 2004. Dhows and the colonial economy of Zanzibar: 1860–1970. Oxford, England: James Currey Ltd. 176 p.

Holling C.S. 1973. Resilience and the stability of ecological systems. Annual Review of Ecology and Systematics 4:1–23.

Holling C.S. 1992. Cross-scale morphology, geometry and dynamics of ecosystems. Ecological Monographs 62(4):447–502.

Holling C.S. 2001. Understanding the complexity of economic, ecological, and social systems. Ecosystems 4:390–405.

Janssen M.A., Bodin Ö., Anderies J.M., Elmqvist T., Ernstson H., McAllister R.R.J., Olsson P., and Ryan P. 2006. A network perspective on the resilience of social-ecological systems. Ecology and Society 11(1):15 [Also available at: http://www.ecologyandsociety.org/vol11/iss1/art15/].

Kvale S. 1996. Interviews: An introduction to qualitative research interviewing. Thousand Oaks, Calif.: Sage. 326 p.

Lee K.N. 1993. Greed, scale mismatch and learning. Ecological Applications 3:560–564.

Levin S. 2000. Multiple scales and the maintenance of biodiversity. Ecosystems 3:498–506.

Montoya J.M., Pimm S.L. and Solé R.V. 2006. Ecological networks and their fragility. Nature 442:259–264.

Newman L. and Dale A. 2005. Network structure, diversity, and proactive resilience building: a response to Tompkins and Adger. Ecology and Society 10(1): r2. [Also available at: http://www.ecologyandsociety.org/vol10/iss1/resp2/]

Ochiewo J. 2004. Changing fisheries practices and their socioeconomic implications in South Kenya. Ocean and Coastal Management 47:389–408.

Tompkins E.L. and Adger W.N. 2004. Does adaptive management of natural resources enhance resilience to climatic change? Ecology and Society 9(2):10. [also available at: http://www.ecologyandsociety.org/vol9/iss2/art10/].

Young O.R. 2002. The institutional dimensions of environmental change. Cambridge, MA: MIT Press. 221 p.

Isostichotoxin isolated from *Isostichopus badionotus* (Selenka, 1867) sea cucumber processing's byproducts

I. Alfonso[1], J.E. Tacoronte[2] and J.A. Mesa[2]

Introduction

Sea cucumbers — mainly from the families Holothuriidae and Stichopodidae — are used both for traditional tonic food and biomedical research (Conand 2006). They constitute an important part of a multi-species invertebrate fishery that has been operating in the Indo-Pacific for traditional and subsistence uses. In the mid- to late-1990s, however, additional markets for sea cucumbers emerged for biomedical research and use for "at home" aquaria (see CITES Secretariat website at: http://www.cites.org 2002). Bioprospectors have become interested in sea cucumbers for natural products research and development. Several commercial products originating from sea cucumber extracts have been marketed in recent years, including ArthiSea and SeaCuMax (arthritis medicines), nutritional supplements, and Sea Jerky (Morgan 2000).

Holothurians contain chondroiton and glucosamine — important cartilage building blocks — and other bioactive substances with anti-inflammatory and anti-tumor activity properties (Mindell 1998; Herecia and Ubeda 1998), as well as fungicidal activity (Darah et al. 1995). Some compounds extracted from holothurians have applications in the prevention and cure of some cancers, and bacterial, fungal or viral infections (Hamel 1997). In Malaysia some medicines and pharmaceutical researches for new products are available from sea cucumbers, such as "gamat oil" "gamat water" "awal gamat" (Baine and Choo 1999; Choo et al. 2004; Zaidnuddin and Kamarruddin 2006).

The bio-actives obtained from *Isostichopus badionotus* processing, began in Cuba in 2003 (Alfonso et al. 2004). These metabolites resulted from processing large amounts of sea cucumbers in boiled sea water as byproduct. This water is usually discarded at sea with no treatment, once cooled. Sea cucumbers are known to produce toxic characteristics and antifungal triterpenoid glycosides of the holostane-type[1-5] with recognized biological actions. Taking into account these results, the current investigation recommends utilizing sea cucumber boiled waste water, and offers a methodology to isolate this metabolite. Other isolated compounds are being currently researched from *I. badionotus* fishery's byproducts.

Boiled sea water is conveniently treated under acidic conditions and the drying process is further submitted to other treatments with solvents (e.g. ethanol and mean polarity eluents), reverse phase conditions with Polycrom–XAD-2, Amberlite and SiO_2 chromatography, thus obtaining the isostichotoxin.

Isolating the toxin

Fifty specimens (15 kg each) of *Isostichopus badionotus* (Fig. 1) were collected in June 2005 by diving at Horiguelas Keyes, located at 20°43.03´N and 78°16.04´W, at depths ranging from 5–12 m and authenticated by Alfonso (*voucher specimen: ISO*-IJ-04), in sampling works. Boiling water (10 L), was filtered, and the aqueous extract was treated, under stirring with 100 mL 10% sulphuric acid (H_2SO_4). The pH was adjusted to 2.8, and the solution was left to stand overnight. The aqueous phase was decanted and ethanol (C_2H_5OH) was added.

The mixture was stirred for 1 h at 25°C, then filtered and the upper layer collected. The pH was then adjusted to 6 and the aqueous phase was concentrated under vacuum and extracted with n-butanol (C_4H_9OH). The butanolic extract was evaporated and separated using column chromatography (XAD-2, Polychrom, 0.5 kg, eluent 0.5–0.7 L 50% ethanol), this eluent was concentrated. The final product (1.0 g) was dissolved in a mixture of ethanol-chloroform-water (100:100:7 v v^{-1} and purified by column chromatography (Silica gel Mesh 60–230, Merck).

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Figure 1. ***Isostichopus badionotus*** **sea cucumber used for processing in Cuba.**

Isostichotoxin,[1] a mixture of natural triterpene glycosides (mp: more than 247°C with decomposition), gives a positive Liebermann-Burchard reaction (steroids and triterpenes), yielding an acid hydrolysis (7% sulphuric acid at 100°C) as a sugar mixture (colored spots with aniline-phosphoric acid reagent). Isostichotoxin has a distinctive maximum in Infrared spectroscopy (FT-IR) at 3300–3500 cm^{-1} and 1745 cm^{-1}. Crude isostichotoxin was purified by recrystallization from methanol (or ethanol) and *in vitro* antifungal activity was tested.

Results were as follows: samples of crystalline isostichotoxin were dissolved as a dimethylformamide aqueous solution of 17.5% to make a 2 mg mL^{-1} solution. The resulting solution was serially diluted with sterile water and added to a series of agar plates, each of which were inoculated with a different organism test. Results are shown in Table 1.

An aqueous alcoholic solution of isostichotoxin at a concentration of 0.01 % was applied to the affected skin of patients, once or several times daily for a period from three days to four weeks. These results are shown in Table 2.

As a preliminary conclusion, isostichotoxin could be used as a potential fungicide mixture for therapeutic treatment of some fungal infections in humans.

References

Alfonso I., Frías M.P., Aleaga L. and Alonso C. 2004. Current status of the sea cucumber fishery in the southeastern region of Cuba. p. 151–159. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.-F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper. No. 463. Rome, FAO. 2004. 457 p.

Baine M. and Choo P.S. 1999. Sea cucumber fishery and trade in Malaysia. The conservation of sea cucumbers in Malaysia: Their ecology, taxonomy and trade. CITES webpage: http://www.cites.org.

Choo P.S. 2004. Fisheries, trade and utilization of the sea cucumbers in Malaysia. p. 57–68. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.-F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper. No. 463. Rome, FAO. 2004. 457 p.

Conand C. 2006. Sea cucumber biology: taxonomy, distribution, biology, conservation status. p. 33–50. In: Bruckner A. (ed.). Proceedings of the CITES Workshop on the conservation of sea cucumbers, NOAA Technical Memorandum, NMFS OPR 34. 244 p.

1. 2005-0236, Cuba, NATURAL FUNGICIDE COMPOSITION, 18 November 2005, J.E. Tacoronte Morales, J.A. Mesa Diaz and I. Alfonso Hernandez

Table 1. **Antifungal activity of *I. badionotus* collected in Cuba's southeastern waters.**

Microorganisms	Minimum inhibitor concentration (mμ mL^{-1})
Trichophyton interdigitale	5.8–6.2
Bacillus subtilis	88
Candida albicans	13.6–16.8
Pseudomonas aeruginosa	79.9–82.3
Mycobacterium tuberculosis	> 100
Microsporus canis	56.3
Escherichia coli	> 100
Torula utilis	2.9
Saccharomyces cerevisiae	2.8

Table 2. **Fungicidal actions on affected skin in patients.**

Effectiveness	Fungus species				
	Pompholyx trichophytia	*Tricophytiaat* (part of lanugo hairs)	*Tinea versicolor*	*Candida erosio interdigitalis*	Number of patients
Very effective	10	1	1	0	12
Effective	7	2	0	1	10
Ineffective	3	1	0	0	4
Total patients	20	4	1	1	26
(%)	77 No side effects were detected during treatment				

Darah I., Stheesh N. and Ibrahim C.O. 1995. Growth inhibition of dermathophites by atratoxins of *Holothuria atra*. Biosci-Penang 6(1):40–48.

Hamel J.F. 1997. Sea cucumber current fishery and prospects for aquaculture. Aquaculture Magazine 23(1):42–43.

Herecia F. and Ubeda A. 1998. Anti-inflammatory activity in mice of extracts from Mediterranean marine invertebrates. Life Sciences 62(9):115–120.

Mindell E. 1998. The supplement bible. New York, New York: Simon and Schuster. 284 p. [also available at: http://www.addall.com/detail/0684856395.html 2000]

Morgan A. 2000. Sea cucumbers in demand. Seafood New Zealand 8(6):69–70.

Zainuddin I. and Kamarruddin I. 2006. National Report Malaysia. p. 169–180. In: Bruckner A.W. (ed). Proceedings of the CITES workshop on the conservation of sea cucumber in the families Holothuriidae and Stichopodidae. NOAA Technical Memorandum NMFS OPR 34. 244 p.

Sea cucumber fisheries around Phu Quoc Archipelago: A cross-border issue between South Vietnam and Cambodia

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Hai Sam is the common Vietnamese name for dry eviscerated sea cucumbers. Dried sea cucumbers are sold in the fish markets of Ho Chi Minh City and exported to mainland China, Hong Kong, Japan, Taiwan and Singapore. More than 10 different edible species are sold in Ho Chi Minh markets, among them are *Holothuria scabra, H. whitmaei Thelenota ananas, Bohadschia argus,* and *Stichopus chloronotus* (Fig. 1). Prices vary according to species and time of the year, between 60,000 to 700,000 Vietnam dong (VND) per kilo (2004, 1 USD = 15,000 VND).

The main fishing grounds for sea cucumbers in the south of Vietnam include the provinces of Khan Hoa, Bin Thuan and Kien Giang. Phu Quoc, which is in Kien Giang Province, is the primary source of sea cucumbers.

Actual trade levels from the southern provinces are unknown. In the south, sea cucumbers are also abundant within the waters of the Koh Sdach and Koh Rong group of islands of Cambodia, close to the Phu Quoc waters of Vietnam, where the locals call them "teak".

Phu Quoc Island lies in the Gulf of Thailand, 45 km from mainland Vietnam and 15 km south of the coast of Cambodia. The island covers an area of 585 km^2 in Vietnam's southwestern waters, and represents the largest island within an archipelago of 14 islands.

Situated on the shallow continental shelf of the tropical monsoon zone and with various geomorphologic and oceanographic conditions, Phu Quoc has a rich variety of marine communities, including some of the most important seagrass areas and coral reefs in the country (Asian Development Bank 1999). Patches of coral communities and sandy-coarse substrate are characteristic habitats of the west coast of the island, especially surrounding small islets and protected bays. Depths may reach 15 m in some of these areas. The east shore of Phu Quoc is characterized by very shallow waters of less than 6 m that extend 6.4 km offshore. Patches of seagrass, sandy and muddy areas are predominant over this coastline. Off the southern tip of Phu Quoc are the An Thoi Islands, a group of small islets with fringing coral reefs and reef flats. Coral communities are common on the west and unexposed zones of the islets (20–25 m depth), while the east is often under the influence of strong currents in steep slopes that might reach depths of 40–60 m. Due to Phu Quoc's geographic location and the territorial ownership disputes between Vietnam and Cambodia, development has, until recently, been quite restricted in the area. However, the growing human population (mostly dedicated to fishing), the increase in trade, and the boom in tourism development, is starting to threaten the coastal ecosystem. Biological resource surveys have been fairly restricted in the past and present knowledge on the demography and spatial distribution of the marine communities is limited (WWF Vietnam 1994; Kanjana 2002; Latypov 2003).

Many Vietnamese believe that sea cucumbers, as with many other marine resources, are highly abundant in Phu Quoc Island. This general understanding is because Phu Quoc is the primary source of origin for many sea cucumber species at Vietnamese food markets. In 2003 and 2004, we obtained several individuals of *H. scabra* from the island in order to carry out pilot culture studies at the College of Fisheries and Aquaculture at Can Tho University, in South Vietnam. Here, we obtained our first reports on the scarcity of sea cucumbers in the area. During 2004, we conducted some field investigations to examine the population of exploitable sea cucumber species around Phu Quoc Archipelago, the status of the exploitation, capture techniques, areas and past history of the fisheries. More information on the species in the area and the status of their populations was obtained by conducting over 80 underwater surveys in the area's shallow waters (down to 18 m depth).

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Figure 1. Sea cucumbers in Cholon market, Ho Chi Minh City.

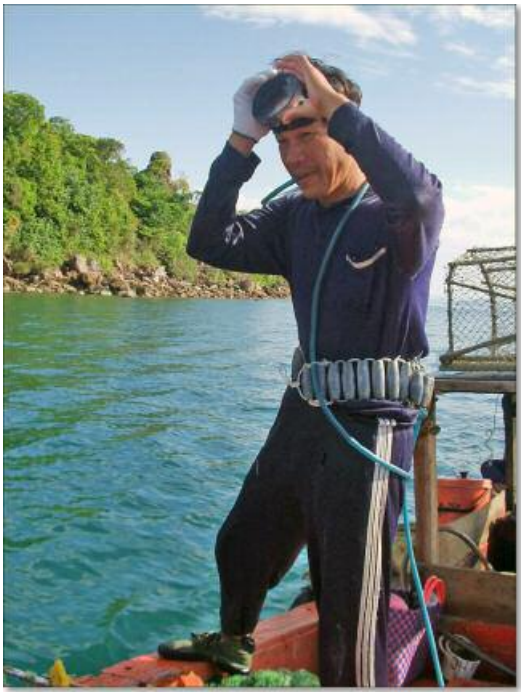

Figure 2. Hookah diver from Phu Quoc Island.

Notes on past and present fisheries around Phu Quoc

Sea cucumber fishing activity in Phu Quoc started in the early 1980s. Initially, sea cucumbers were caught using large poles from boats on shallow waters but as the shallow water sea cucumber populations decreased, hookah divers replaced the pole fishing activity. Some sea cucumber species that are rarely seen nowadays, such as *H. scabra*, were commonly found in very shallow waters around the archipelago. The sea cucumber fishery boomed in the late 1980s with divers from many fishing communities around Phu Quoc dedicated to this type of fishing. By 1992, the average catch per diver was 20 kg (dry weight) per day for some sea cucumber species (e.g. *Holothuria leucospilota*, *Stichopus herrmanni* or *Bohadschia argus*).

Nowadays, most hookah divers (Fig. 2) collect sea cucumbers at night using torches in waters as deep as 30–40 m. The fishery is year round when weather permits, except during nights when clear skies and a full moon coincide. The divers explained that during these nights, and during the monsoon season (months of June and July), sea cucumbers remain buried in the sand or hidden in the crevices of corals and rocks.

The average monthly income for a sea cucumber diver in Vietnam might reach 2–3 million VND, equivalent to USD 130–194 (2004). However, as sea cucumber numbers decline, divers are beginning to target other fauna. Fishermen also occasionally catch sea cucumbers, particularly *H. scabra*, when fishing for swimming crabs with fine nets and on fishing trawlers. Today, sea cucumber fishermen only occasionally dive in South Vietnamese waters due to the sharp decrease in stocks during the last five years. Fishing activity, especially during the dry season, is now concentrated in Cambodian waters. Dive boats (12 m long and 4 m wide) with four or five divers travel for one or two days to harvest sea cucumbers in the far islands of Kaoh Mano, Kaoh Rong, Kaoh Rung and Kaoh Kong. Divers are normally away for 10 to 20 days (depending on the amount of catch), returning home during the days of full moon. Nevertheless, interviews with sea cucumber divers revealed that although Cambodian stocks are still abundant, there has been a decline in the capture rate. The number of dive boats has also increased in these waters. Most Vietnamese fishermen that previously were dedicated to harvesting sea cucumbers have moved to other fishing activities. The main reasons given for this are related to the increasing difficulty in finding sea cucumbers in and outside Phu Quoc Archipelago and the low monetary return received for time spent diving. Moreover, illegal fishing in Cambodian waters is considered a dangerous activity and Cambodian coastguards are increasing both the number and amounts of fines for Vietnamese dive boats.

Local trade in sea cucumbers

The sea cucumber trade in Phu Quoc has decreased considerably over the years as stocks have diminished. Dried sea cucumbers are sold mainly to Ho Chi Minh City. Their trade began in 1978 and mainly focuses on one species, the sandfish, *H. scabra*. By 1994, Phung (1994) reported that five target species, *H. scabra*, *H. leucospilota*, *H. edulis*,

H. atra and Actinopyga echinites were commercialized from the south Vietnamese coastal zone. After the boom in their exploitation during the last decade, captures declined and five years ago, most shops in the island stopped trading sea cucumbers. Some sea cucumber buyers also indicated a decline in catches of sea cucumbers after Typhoon Linda in 1997. Table 1 gives some examples of harvests before and after the typhoon.

Those who still trade sea cucumbers chose to broaden the number of targeted species to 8–12 different types. As the divers reported, most sea cucumber fishing nowadays occurs in Cambodia and the farthest islands of the Phu Quoc Archipelago. The target species are mainly *Holothuria atra, H. leucospilota, H. edulis, H. fuscopunctcta, H. scabra, Stichopus naso, S. ocellata, S. herrmanni S. chloronotus, Bohadschia marmorata, B. argus,* and *Thelenota ananas.*

Table 2 shows the scientific, English and local names of the edible species of sea cucumbers collected around the area.

Table 1. Examples of sea cucumber harvests before and after Typhoon Linda.

Species	Harvests before 1997	Harvests after 1997
Holothuria scabra	200–500 kg year^{-1} (dry weight)	Less than 100 kg year^{-1} (dry weight)
Holothuria atra	Many tonnes year^{-1} (dry weight)	Less than 1 t year^{-1} (dry weight)
Holothuria leucospilota	Many tonnes year^{-1} (dry weight)	100 kg year^{-1} (dry weight)
Stichopus herrmanni	1 t day^{-1} (fresh weight)	10 kg day^{-1} (fresh weight)
Total amount	5 t year^{-1} (dry weight)	500 kg year^{-1} (dry weight)

Table 2. Scientific, commercial and local names of sea cucumbers in Phu Quoc plus average price in Vietnam dong, 1 USD = 15,000 VND (2005).

Scientific name	English name	Local name	Average value (VND kg^{-1} dry weight)
Holothuria scabra	Sandfish	Đột trắng	500,000–700,000
Holothuria atra	Lollyfish	Đĩa đen , đia máu	40,000
Holothuria leucospilota		Đĩa mũ	20,000
Holothuria edulis	Pinkfish	Sâu gai	50,000
Holothuria fuscogilva	White teatfish		
Holothuria whitmaei	Black teatfish	Đột đen đá	
Holothuria fuscopunctata	Elephant trunkfish	Đột đá, đột da trăn	80,000
Stichopus chloronotus	Greenfish	Sâu biển, đột bê ơ	250,000–300,000
Stichopus herrmanni	Curryfish	Đột ngận đá, đột ngận trường	>300,000
Stichopus horrens		Đột ngận	
Thelenota ananas	Prickly redfish	Đột điều	800,000
Thelenota anax	Amberfish	Đột khoai lang	
Bohadschia marmorata	Brown sandfish	Đột mủ	100,000
Bohadschia argus	Tigerfish	Đột da trăn, Sâm vàng	300,000
Pentacta anceps		Đột bí đao	
Pentacta quadrangulis		Đột gai đổ	130,000
Pearsonothuria graeffei	Flowerfish	Đột dải, đột dải đá or dâu đá (small)	

Sea cucumber processing

The divers process the sea cucumbers themselves. If evisceration has not taken place in the boat, the sea cucumbers are squeezed to force the ejection of the guts and water, or a small cut is made. They then are washed with clean seawater and boiled. Special care is taken with *H. scabra*. After boiling they are buried in a bag in sand for some days and then sun dried.

Spatial abundance of exploitable species of sea cucumbers

There have not been previous sea cucumbers surveys in the island and the lack of information on habitat variability restricts the possibility of quantifying the status of these populations at present. Nevertheless, this survey is the first account on the species, general abundance in surveyed areas, and habitat description.

Twenty-five species of sea cucumbers were found in Phu Quoc Archipelago. Eleven of these species are edible and exploited commercially, but *H. scabra* is the most valuable by far. *H. scabra* was never encountered during our dive survey although local fishermen using crab nets occasionally see some live individuals.

Other common species of low commercial value were *H. leucospilota*, *H. atra* and *H. edulis*. These species were found in very low densities and had a patchy distribution. *H. edulis* was found in habitats with rubble and scattered rocks at the edge of the reef between 8 and 15 m depths, whereas *H. atra* was encountered in shallow waters on sand flats, among rocks or in mixed seagrass beds. As with *H. atra*, the black sea cucumber *H. leucospilota* was present all over the island, although more commonly in intertidal waters.

Stichopus ocellata aggregates in shallow mixed seagrass beds and on coarse sand among coral reefs (Fig. 3). Two colour morphs were distinguished: one is a light uniform brown morph and the other has dark chestnut spots over the dorsal surface. This species is found exclusively among bivalve beds and mixed seagrass-algae beds in the east of the island. A few individuals of other species of the genus *Stichopus* were also found (Fig. 3). *S. chloronotus* was only seen in the farthest Vietnamese islands of the archipelago and *S. herrmanni* and *S. naso* were present on only two occasions during the entire survey period.

Bohadschia species, *B. bivittata* and *B. argus* (according to classification of Clouse et al. 2005), were rare and exclusively sited at the An Thoi islands in depths of more than 12 m. *B. vitiensis* was found buried on sand reef flats at 17 m in the farthest islands. *Pearsonothuria graeffei* was only recorded on the reefs of one island of An Thoi, exposed on natural blocks. It seems that this species was more active (and visible) on days with high ocean currents.

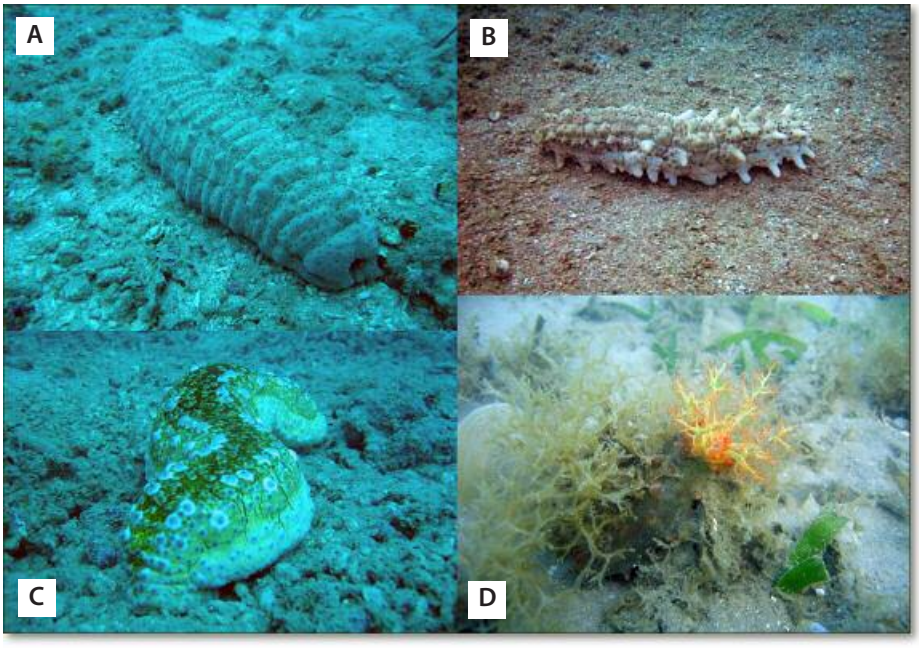

Figure 3. Sea cucumber species from Phu Quoc.
A. *Stichopus herrmanni*; B. *Stichopus ocellatus*,
C. *Stichopus naso*, D. *Pentacta quadrangulis*.

The help of C. Massin and Y Samyn in identification is acknowledged.

Overall, the density of all sea cucumbers in the surveyed area was found to be very low. Taking into account the comments from the divers and traders, it seems that the present situation is probably a consequence of many years of uncontrolled fishing. Other low commercial species showed a very patchy distribution, often concentrated in a single transect line (50 m), hidden under sand or between rocks, coral crevices, or seagrass and not reappearing for kilometres. Species such as *H. scabra* and *S. herrmanni*, once highly abundant, are nowadays rare, a prediction of nearby future local extinctions. As in many other Indo-Pacific countries, fishing effort has also switched from high to low value commercial species, and going to deeper and more remote waters (Uthicke and Conand 2005). Sea cucumber harvesting has now moved to neighbouring Cambodian waters, but the products enter into the Vietnamese market through Phu Quoc and are labelled as a domestic product, rather than imported. Consequently, Vietnamese market stocks still maintain a good supply of products.

Phu Quoc Archipelago serves as an important ecological transition area between the South China Sea and the Gulf of Thailand. The dynamics and status of the sea cucumber populations between the islands and the supply from other areas will need to be provided in order to characterize the natural fluctuations. Further studies concerning the fisheries activities in Phu Quoc Archipelago and neighbouring Cambodian islands are necessary in order to elucidate the interaction between fisheries and the yield of commercial sea cucumber species. Fishing effort needs to be regulated for all commercial species of sea cucumbers. A co-management programme between both countries to regulate sea cucumber fishing in these waters will not work unless it has the full support of local communities. Working and collaborating with fishermen and conducting environmental education campaigns will be most important for making this a success.

References

Asian Development Bank 1999. Draft Coastal and Marine Protected Area Plan 2:163–167.

Close R., Janies D. and Kerr A.M. 2005. Resurrection of *Bohadschia bivittata* from *B. marmorata* (Holothuroidea: Holothuriidae) based on behavioral, morphological, and mitochondrial DNA evidence. Journal of Zoology 1:27–40.

Kanjana A. 2002. Report of dugong and seagrass survey in Vietnam and Cambodia. Report from Phuket Marine Biological Center, Thailand.

Latypov Y.Y. 2003. Reef building corals and reefs of Vietnam: The Gulf of Thailand. Russian Journal of Marine Biology 29:1:S22–S33.

Phung Nguyen Huu. 1994. Surveying special marine products of coastal zones of mainland and island in Vietnam. Unpublished scientific report.

Uthicke S. and Conand C. 2005 Local examples of beche-de-mer overfishing: An initial summary and request for information. SPC Beche-de-mer Information Bulletin 21:9–14.

WWF Vietnam Marine Conservation Southern Survey Team. 1994. Survey report on the biodiversity, resource utilization and conservation potential of Phu Quoc (An Thoi) islands, Kien Giang Province. Institute of Oceanography (Nha Trang, Viet Nam) and WWF. Unpublished report. 80 p.

Acknowledgements

This work was made possible thanks to funding provided by the Rufford Fund for Nature Conservation, PADI Aware Fund, and the Spanish Agency for International Cooperation (AECI). We also thank Mr Tran Manh, Dr Mark Walton, Dr Truong Trong Nghia, Mr Nguyen Van Lanh, and Dr Nguyen Anh Tuan at the College of Fisheries and Aquaculture at Can Tho University. Phu Quoc Rainbow Divers and local authorities from Kien Giang and Phu Quoc provided all the logistical support. Special thanks to all fishermen from Phu Quoc Island for all their support and sharing their knowledge.

In situ observation of sexual reproduction in *Stichopus chloronotus* at a fringing reef at Reunion Island (Indian Ocean)

Barrère A.[1] *and Bottin C.*[1]

Of the 17 sea cucumber species found to date in the reefs of Reunion Island (Conand and Mangion 2002) *Stichopus chloronotus* is one of the dominant ones. Population abundance varies depending on the reef. For example, this sea cucumber is rare at the Toboggan and Planch'Alizés sites (Saint Gilles/La Saline Reef) and at Saint Pierre and Saint Leu Reefs, but is abundant at Etang Salé Reef and very abundant at the Trou d'eau site (Saint Gilles/La Saline Reef). *S. chloronotus* is one of nine sea cucumber species capable of reproducing both sexually — through release of gametes — and asexually — through transverse fission (Conand 2002).

Conand, Uthicke and Hoareau (2002) showed that sexual reproduction in *Stichopus chloronotus* has distinct seasonal characteristics, with spawning during the hot season (November to February), in both Reunion Island and on the Great Barrier Reef in Australia.

We observed and photographed the release of genital matter by *Stichopus chloronotus in situ* at Etang Salé Reef after the full moon in December 2006. This was the first time that sexual reproduction in this species had been observed on site at Reunion Island.

Figure 1. ***S. chloronotus*** **in spawning posture** (photo Barrère)

The initial observations took place by accident at 6 p.m. on 7 December (i.e. two days after the full moon). The zone, which was explored using snorkelling gear (fins, mask and snorkel), was the southern half of the "Bassin pirogue" (the Etang Salé reef flat), which is used for anchorage by about 100 small vessels. The substrate there is sandy (mixed origin, coral and especially basalt), with a depth of about one meter. The current is almost always south–north towards the navigation channel. Other observations were made on 8 and 9 December, in the morning at about 9 a.m. and at the end of the day between 5:00 and 6:30 p.m. (sunset). *Stichopus chloronotus* is the most abundant sea cucumber species in this zone, with a density of about two specimens per metre. The Southern Hemisphere winter began several weeks late in 2006.

In the first instance, on 7 December, we observed the characteristic posture for sexual reproduction in sea cucumbers: the animals were stretched out towards the surface with the front part of their body up (2/3 of the body) and the back part lying on the bottom (Fig. 1). In one hour, we found four specimens with this posture in an area of about 150 m^2. We were able to observe two instances where gametes were released, without any forewarning, rapidly and massively, in the form of a white "cloud". On the morning of 8 December, no instances of sexual reproduction were observed. At the end of the day on 8 December, between 5:00 and 6:30 p.m., six specimens were observed in the process of reproducing. The sea cucumbers were isolated except for two that were side by side on a boat anchor block. Gamete release was observed in three specimens. The gametes were expulsed in a continuous flow in the form of a fine thread coming out of the genital orifice (Fig 2, probably a male). For one sea cucumber, the gametes, visible in macrophotography, are identifiable as oocytes (Fig. 3). On 9 December we did not observe any specimens in the reproductive posture or any spawning in either the morning or at the end of the day. Further exploration of the reef flat on 12, 17

1. Association Vie Océane - La Réunion. http://vieoceane.free.fr/index.html

and 19 December confirmed that the phenomenon had ended.

References

Conand C. 2002. La vie sexuelle des holothuries. Pour La Science 292:19–20.

Conand C. and Mangion P. 2002. Holothurians from La Réunion fringing reefs: Diversity, distribution, abundance and population structure. SPC Beche-de-mer Information Bulletin 17:27–33.

Conand C., Uthicke S. and Hoareau T. 2002. Sexual and asexual reproduction of the holothurian *Stichopus chloronotus* (Echinodermata) : a comparison between La Réunion (Indian Ocean) and east Australia (Pacific Ocean). Invertebrate Reproduction & Development 41(1–3):235–24.

Figure 2.
Release of sperm by a male *S. chloronotus*
(photo Barrère)

Figure 3.
Release of oocytes by a female *S. chloronotus*
(photo Barrère)

Facts on sea cucumber fisheries worldwide

M. Verónica Toral-Granda[1]

Sea cucumber fisheries occur worldwide, from monospecific temperate fisheries to multispecific tropical ones. These fisheries currently involve 49 species (Table 1) that yield products such as beche-de-mer and which provide an important source of income to coastal communities. The trade in sea cucumbers has resulted in many species being overharvested, which endangers their natural viability, and which has lead to debates about their conservation and sustainability in various fora in recent years (e.g. ASCAM and CITES workshops).

With the main objective to provide scientific tools aiming towards the conservation of sea cucumber populations worldwide, the Food and Agricultural Organization of the United Nations (FAO) developed a project aimed at collating and disseminating information on the global status of commercially exploited sea cucumber populations, and helping to improve capacity within selected developing countries for the conservation and sustainable use of sea cucumbers. This project has different activities that include the preparation of a comprehensive guide of commercially valuable sea cucumbers to help research, management, enforcement and control, both at the national and international level. Although the original idea for this FAO publication was a simple identification guide, it has now become a compilation of available scientific information on the biology, ecology, marketing and processing of sea cucumbers, and includes photos and descriptions of commercially valuable species at different processing levels. This project is currently under the overall coordination of the author of this paper.

The relevant information was collated by means of a questionnaire developed jointly by the author and FAO. The questionnaire included information on habitat, reproductive biology (size at maturity, reproductive season, mean fecundity, larval development type, egg diameter), type of fishery (subsistence, artisanal, semi-industrial and industrial), the author's knowledge on the population's status (overfished, stable, in decline, unknown), main market, main use (beche-de-mer, medicinal, fermented intestines, dried gonad), management strategies implemented (none, minimum size, fishing season, permits, no-take zones, moratorium/ban, gear restrictions, other), fishing methods used, and domestic consumption. A brief description of this project, including a call for information, was published in the SPC *Beche-de-Mer Information Bulletin* #24 (Toral-Granda 2006).

Table 1. List of commercially important sea cucumber species in the families Cucumariidae, Holothuriidae and Stichopodidae.

Cucumariidae		
Athyonidium chilensis	***Cucumaria frondosa***	*Pattalus mollis*
Holothuriidae		
Actinopyga agassizi	***A. echinites***	***A. lecanora***
A. mauritiana	***A. miliaris****	*A. palauensis*
A. serratidens	*A. spinea*	***Bohadschia argus***
B. atra	***B. marmorata vitiensis****	***B. similis***
B. subrubra	***B. vitiensis****	*Holothuria arenicola*
H. (Halodeima) atra	*H. cinerascens*	***H. coluber***
H. edulis	***H. fuscogilva****	***H. fuscopunctata***
H. impatiens	***H. hilla***	*H. leucospilota*
H. mexicana	***H. nobilis****	***H. scabra***
H. scabra versicolor*	***H. spinifera***	***H. whitmaei***
Pearsonothuria graeffei		
Stichopodidae		
Astichopus multifidus	***Isostichopus badionotus***	***I. fuscus***
Parastichopus californicus	*P. parvimensis*	***Stichopus chloronotus***
S. herrmanni (*S. variegatus*)*	***S. horrens***	*S. (Apostichopus) japonicus*
S. mollis	***S. ocellatus***	***S. vastus***
Thelenota ananas	***T. anax***	*T. rubralineata*

Species names in bold are those that provide information used in the present publication.
* species that need taxonomic review.

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The present document aims to summarise the information provided in such cards in areas of interest to scientists and managers of sea cucumber populations and to encourage fellow colleagues to provide information on their species of expertise and areas of interest. The card template is available upon request.

Results

Based on personal communication with 19 sea cucumber researchers worldwide, 66 cards have been received, representing 34 species of sea cucumbers from 18 countries (Table 2). Mauritius appears in two columns as two authors presented cards for that country (Prof C. Conand and Dr A. Laxminarayana). Further evaluation of the cards presented will allow for the identification of the final number of species present in Mauritius.

Information on the reproductive biology of the 34 species reported by the authors is spotty: there is no information for 22 species, information for 5 species coming from only certain parts of their geographical distribution, and complete information for only 7 species (e.g. *C. frondosa* in Canada or *B. marmorata* in Mauritius). For some species there is information on the reproductive season, mean

Table 2. Cards received per species of commercially important sea cucumbers.

Species	Australia	Canada	Cuba	Ecuador	Egypt	India	Mad, Com, Ken, Mau, May, Sey*	Malaysia	Mauritius	Mexico	New Zealand	Philippines	PNG**	Total
Actinopyga echinites						1			1				1	3
Actinopyga lecanora						1							1	2
Actinopyga mauritiana					1	1							1	3
Actinopyga miliaris						1							1	2
Actinopyga serratidens						1								1
Bohadschia argus						1							1	2
Bohadschia atra							1							1
Bohadschia marmorata						1			1					2
Bohadschia similis													1	1
Bohadschia vitiensis						1							1	2
Cucumaria frondosa		1												1
Holothuria atra					1	1			1				1	4
Holothuria coluber													1	1
Holothuria edulis						1							1	2
Holothuria fuscogilva					1	1							1	3
Holothuria fuscopunctata													1	1
Holothuria hilla												1		1
Holothuria nobilis					1			1	1					3
Holothuria scabra	1				1	1			1				1	5
Holothuria spinifera						1								1
Holothuria versicolor	1													1
Holothuria whitmaei													1	1
Isostichopus badionotus			1											1
Isostichopus fuscus				1						1				2
Parastichopus californicus		1												1
Pearsonothuria graeffei					1	1							1	3
Stichopus chloronotus						1			1				1	3
Stichopus hermanni					1	1							1	3
Stichopus horrens						1							1	2
Stichopus mollis											1			1
Stichopus ocellatus	1													1
Stichopus vastus	1					1								2
Thelenota ananas						1			1				1	3
Thelenota anax													1	1
Grand total	4	2	1	1	7	19	1	1	7	1	1	1	20	66

* Madagascar, Comores, Kenya, Mauritius, Mayotte and Seychelles

** Papua New Guinea

fecundity, size at maturity, type of larval development and egg diameter (e.g. *Isostichopus fuscus* in the Galapagos islands), while for others, information is available on certain biological aspects only. The most common information is the time of the year that a species reproduces.

On the management strategy, there are only two species — *Bohadschia atra* and *Holothuria hilla* — for which there is no management plan in place. Other species are managed in some countries, but not everywhere (e.g. regulations for *A. echinites* include a ban in India, a minimum landing size, a fishing season, permits, TACs, and gear restrictions in Papua New Guinea, but the same species is not regulated in Mauritius). Minimum size limit is the most common type of management strategy reported, appearing in 28 cards, followed by a limited fishing season (25 cards), and gear restrictions (23 cards). Sea cucumber fishing activities have been banned in India since 2001. There is one record of the use of individual transferable quotas (ITQs) for *P. californicus* in Canada.

On the type of fishery, seven species are exclusively under artisanal exploitation (i.e. *T. anax* and *H. whitmaei* in PNG, *H. hilla* in the Philippines), three under industrial (*P. californicus* and *C. frondosa* in Canada, and *H. versicolor* in Australia), and one under semi-industrial exploitation (*S. mollis* in New Zealand). In the case of *H. spinifera* and *A. seraratidens* in India, these species sustained a semi-industrial fishery until this activity was banned by the government in 2001. The remaining species are under different types of fisheries, with one species (*H. scabra*) under four types of exploitation depending on the country.

Sea cucumbers are mostly harvested to supply the beche-de-mer market (63 cards), but also for the use of their fermented intestines (*H. hilla* in India), their muscle strips (*P. californicus* in Canada), or for medicinal purposes (*C. frondosa* in Canada, *P. graeffei* and *S. hermanii* in Egypt). Some species have several uses. The main market is Asia with Singapore, China and Hong Kong Special Administrative Region as the main importation ports. Domestic consumption was reported only for *H. hilla* in the Philippines, *H. nobilis* in Malaysia, *H. scabra* in Australia, *P.graeffei* in Egypt, *P. californicus* in Canada, *S. mollis* in New Zealand, and *S. herrmanii* in Egypt.

Based on the information provided by the authors, a total of 28 species are considered to be overexploited, 11 in stable condition, 3 in decline, and 24 in unknown conditions. Some species reportedly have different population status in different countries (e.g. *H. atra*, is classified as stable in Mauritius, in decline in Egypt, overexploited in India and in unknown condition in PNG).

More contributions needed

From the total number of species identified as being commercially important, there are still 16 species for which there is no information. Additionally, there are several other species that have wider distribution ranges that, ideally, we would like to cover.

I urge fellow colleagues who have information on any of the above-mentioned species, or on other species of commercial interest, to provide the information requested. If you do not have the template, please contact me so I can send it to you. Filling in the template should take no more than 30 minutes of your time, and it will be a great help for the overall success of this project.

For further information, please contact:

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Conclusions

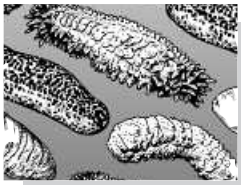
These cards have yielded important information on the current status of knowledge and management of commercially important sea cucumber populations. Upon completion, the final product could become a useful guide to improve current management practices that will help conserve sea cucumber populations worldwide. Authors who have not contributed so far are encouraged to send their information in order to provide the first up-to-date global summary of information of sea cucumber species of commercial interest.

Acknowledgements

Many thanks to A. Laxminarayana, A. Mercier, B. Giraspy, C. Conand, D.B. James, E. Wylie, G. Ivy, I. Alfonzo, J.F. Hamel, J. Kinch, K. Muthiah, M. Baine, M.A. Sewell, M.D. Herrero-Perezrul, M.I. Ahmed, P. Polon, P.S. Choo, R. Gamboa and T. Skewes who kindly provided the information cards used for this preliminary analysis. Alessandro Lovatelli from FAO provided comments and suggestions to improve this document. This is Charles Darwin Foundation contribution # 1051.

Reference

Toral-Granda M.V. 2006. Fact sheets and identification guide for commercial sea cucumber species. SPC Beche-de-Mer Information Bulletin 24:49–52.



Abstracts & publications
beche-de-mer

Proceedings of the CITES Workshop on the Conservation of Sea Cucumbers in the Families Holothuriidae and Stichopodidae

Bruckner A. (ed).

Source: Proceedings of the CITES Workshop on the Conservation of Sea Cucumbers in the Families Holothuriidae and Stichopodidae. NOAA Technical Memorandum; NMFS-OPR 34, 244 p. 2006.

The Proceedings on the CITES Workshop on the Conservation of Sea Cucumbers in the Families Holothuriidae and Stichopodidae are now available. The workshop (1–3 March 2004 in Kuala Lumpur, Malaysia) was attended by 56 representatives from governments of exporting and importing countries, universities, industry, and NGOs in response to a decision adopted at the 12th Conference of Parties to CITES on sea cucumbers. This decision requested that the CITES Animals Committee review biological, fishery and trade information for commercially important sea cucumber species, and identify possible national, regional and international conservation mechanisms to ensure that the harvest and trade in these species is sustainable. The Proceedings includes position papers on 1) the biology, taxonomy and distribution of commercially important sea cucumbers species; 2) the main species in trade and the origin, trade routes and utilization patterns; 3) current fishing practices and management options; and 4) opportunities for sustainable wild harvest and trade controls. There are also reports from 18 participating countries and three working group reports on (i) national fisheries management; (ii) priorities for international conservation and protection; and (iii) potential CITES implementation issues.

The primary threat to sea cucumber populations identified by the participants at this workshop was overexploitation to supply growing international markets for beche-de-mer and other products. Sea cucumbers are prone to overexploitation due to their life history (e.g. limited mobility as adults, late sexual maturity, density-dependent reproduction, and low rates of recruitment) and ease of collection (adults are large, often diurnal, easy to detect and collect, and do not require sophisticated fishing or processing techniques). Historical reports describe a 'boom-and-bust' cycle, where over-exploitation of traditional fishing grounds has prompted fishers to expand into deeper water, move to new locations, and target less valuable species. World sea cucumber capture fisheries increased approximately 500% between 1950 and 2000, with the largest growth since the 1980s. Increases are largely due to: 1) larger numbers of producing countries; 2) greater numbers of species harvested; and 3) expansion of fishing activities into remote locations and deepwater habitats.

The two most urgent needs for sea cucumber conservation identified during this workshop were the development of national fishery management plans and harmonized trade reporting. Management plans should include specific regulations adopted through an adaptive management process, with emphasis on size limits, quotas, spatial closures, and other mechanisms as appropriate under particular situations. These plans should also address bycatch and habitat impacts associated with certain gear types, include development of aquaculture and restocking programs, and involve implementation of national monitoring programs that emphasize stock assessments and collection and analysis of fisheries data. While there was no specific endorsement for additional CITES listings, there was recognition that certain species qualify for listing. CITES listings could offer substantial benefits by preventing illegal trade and harvest, and ensuring that exports are sustainable. Additional CITES listings could help promote increased partnerships with importing countries, non-government organizations and sea cucumber experts, and provide a mechanism for comprehensive and standardized trade and quota reporting. Furthermore, future listings could contribute to enhanced opportunities for technical assistance and capacity building and the development of Regional Fishery Management Organizations for sea cucumbers. Implementation of additional CITES listings would also place additional burdens on exporting and importing countries, due to permitting requirements, paucity of information needed to make non-detriment findings, and enforcement problems associated with taxonomic discrepancies and difficulties in identifying sea cucumbers, especially in a processed state. Some of the critical information needs that could contribute to national management and facilitate successful implementation of possible CITES listings include 1) research on taxonomy, with emphasis on identification tools and marking schemes; 2) basic biological and ecological research; 3) improved collection, reporting and sharing of fishery-dependent data; 4) adoption of field monitoring programs; 4) improved education, training and dissemination of information and tools; and 5) improved enforcement capacity to address poaching and illegal trade.

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The abundance and distribution of holothurians (Echinodermata: Holothuroidea) in the shallow coastal lagoon of Rodrigues, Mauritius

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Source: MSc Thesis presented at the School of Ocean Sciences, University of Wales, Bangor, Menai Bridge, Anglesey, LL59 5AB, UK. 2006.

The island of Rodrigues, Mauritius, has recently been established as a producer for the expanding beche-de-mer industry and there is a critical requirement for information concerning its resident holothurian populations. The current study aimed to provide baseline data regarding the distribution of holothurian species inhabiting its shallow lagoon. During July and August 2006, a total of 1,678 holothurians were recorded at 41 survey sites (7,380 m^2), representing six aspidochirotid, one apodid and one dendrochirotid species. It was estimated that 48.3 million holothurians inhabited the lagoon. The most dominant and widespread species was *Holothuria atra* (71.68% of individuals). The next most common species were *H. leucospilota*, *Stichopus chloronotus* and *Synapta maculata* (11.08%, 10.85% and 5.24%). The exploited species *Actinopyga mauritiana* was rarely observed (0.66%). Differences between lagoon region and habitat type were examined. Species distributions were heterogeneous, and three areas have been distinguished for their abundant holothurian fauna. The northeast region harboured high mean densities of *H. leucospilota*, *Stichopus chloronotus* and *Synapta maculata* (0.233, 0.367 and 0.106 m^{-2}) and exhibited significantly higher species diversity (H' = 0.638) than other regions. The highest overall mean densities were found close to shore at the western end of the island, comprising predominantly *H. atra* (maximum 0.728 m^{-2}). Species distributions were strongly related to the measured percentage cover of vegetation, as well as that of sediment. Overall density was significantly greater at vegetation sites than coral/rubble and sediment sites (0.354, 0.177 and 0.193 m^{-2}) and diversity was significantly lower at sediment sites than coral/rubble and vegetation sites (0.116, 0.482 and 0.470). Diversity correlated positively with percentage cover of macroalgae and rubble, and negatively with percentage cover of sediment. There were few clear patterns in length for different species. *H. atra* displayed a negative relationship between length and population density, and length was significantly greater at coral/rubble sites than sediment and vegetation sites (18.98, 15.72 and 14.47 cm). Substratum and shelter associations of holothurian species closely reflected site habitat characteristics. *H. atra* and *H. leucospilota* were primarily associated with sediment substrata, and *Stichopus chloronotus* and *Synapta maculata* were associated with rubble substrata. Individuals of *H. leucospilota* and *Synapta maculata* were frequently under cover (55.5%), whereas *H. atra*, *Stichopus chloronotus* and other species were mostly uncovered (90.3%). Recommendations for sustainable management of holothurian resources are proposed

Effect of invasive tagging on the activity of *Holothuria whitmaei* [Echinodermata: Holothuroidea]: A suitable mark-recapture method for short-term field studies of holothurian behaviour

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Source: Marine and Freshwater Behaviour and Physiology 39(2):153–162. 2006.

Although mark-recapture techniques traditionally have been used to obtain ecological data, tagging of soft-bodied holothurians has proven difficult, and the degree to which invasive tags may confound the behaviour of holothurians remains unclear. In this study, diurnal patterns of activity were monitored in the commercial sea cucumber *Holothuria whitmaei* (black teatfish) after marking the tegument superficially with a number measuring 30 ± 20 mm (to a depth of ≤ 2 mm). Rates of activity in marked specimens increased significantly in the initial hours following marking, and remained higher than those of unmarked control animals for up to 3 days following the procedure. These results suggest (a) that behaviour in holothurians may initially be compromised by marking the tegument and (b) that improved measures of activity may be obtained following a suitable recovery period. This is a useful finding given the need for improved knowledge of commercial holothurian biology, including diurnal and seasonal patterns of behaviour.

Tensilin-like stiffening protein from *Holothuria leucospilota* does not induce the stiffest state of catch connective tissue

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Source: Journal of Experimental Biology 209:1594–1602. 2006.

The dermis of sea cucumbers is a catch connective tissue or mutable connective tissue that exhibits large changes in mechanical properties. A stiffening protein, tensilin, has been isolated from the sea cucumber *Cucumaria frondosa*. We purified a similar protein, *H*-tensilin, from *Holothuria leucospilota*, which belongs to a different family to *C. frondosa*. *H*-tensilin appeared as a single band with an apparent molecular mass of

34 kDa on SDS-PAGE. No sugar chain was detected. Tryptic fragments of the protein had homology to known tensilin. *H*-tensilin aggregated isolated collagen fibrils *in vitro* in a buffer containing 0.5 mol L^{-1} NaCl with or without 10 mmol L^{-1} Ca^{2+}. The activity of *H*-tensilin was quantitatively studied by dynamic mechanical tests on the isolated dermis. *H*-tensilin increased stiffness of the dermis in the soft state, induced by Ca^{2+}-free artificial seawater, to a level comparable to that of the standard state, which was the state found in the dermis rested in artificial seawater with normal ionic condition. *H*-tensilin decreased the energy dissipation ratio of the soft dermis to a level comparable to that of the standard state. When *H*-tensilin was applied on the dermis in the standard state, it did not alter stiffness nor dissipation ratio. The subsequent application of artificial seawater in which the potassium concentration was raised to 100 mmol L^{-1} increased stiffness by one order of magnitude. These findings suggest that *H*-tensilin is involved in the changes from the soft state to the standard state and that some stiffening factors other than tensilin are necessary for the changes from the standard to the stiff state.

Other recent publications:

Agudo N. 2007. Sandfish hatchery techniques. Australian Centre for International Agricultural Research (ACIAR), the Secretariat of the Pacific Community (SPC) and the WorldFish Center. Noumea, New Caledonia. 44 p.

[also available at: http://www.spc.int/coastfish/Reports/Worldfish/Sandfish_hatch_tech.pdf, http://www.worldfishcenter.org, and http://www.aciar.gov.au]

Given the overexploitation of sandfish, programs to release juveniles to the wild, "put and take" sea ranching operations and tank or sea pen hatcheries for juveniles could help restore the populations of this sea cucumber, which has a very high market value. This manual is designed to help government agencies and members of the private sector interested in implementing any of the methods mentioned above.

The manual outlines the basic methods for spawning and rearing juvenile sandfish. It builds on the pioneering work done in 1988 at the Tuticorin Research Centre of CMFRI (Central Marine Fisheries Research Institute) in India and is based largely on methods developed and applied by the WorldFish Center (formerly ICLARM) in the Solomon Islands, Vietnam and New Caledonia.

The information in the manual will enable hatcheries to produce sandfish suitable for release to the wild in relatively large numbers (tens of thousands) on a regular basis. However, it does not pretend to be fully comprehensive, rather, it is a reflection of current knowledge.

Kirshenbaum S. and Chen Y. 2006. A study of tagging methods for the sea cucumber *Cucumaria frondosa* in the waters off Maine. Fishery Bulletin 104:299–302.

Rasolofomanana Voahangiarilala L. 2006. Contribution a l'analyse de l'exploitation des holothuries dans la baie de Ramanetaka dans le cadre de la création d'une APMC aux îles Radama/Sahamalaza. Master report, Toliara University, Madagascar. (in French)

Thandar A.S. 2005. Two new species of *Stolus selenka* (Echinodermata: Holothuroidea: Dendrochirotida: Phyllophoridae) from off the east coast of South Africa, with a revised key to the genus. African Zoology 40 (1):115–126.

Thandar A.S. 2006. New species and new records of dendrochirotid and dactylochirotid holothuroids (Echinodermata: Holothuroidea) from off the east coast of South Africa. Zootaxa 1245:1–51.

Original text: English

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